

N7676874



A20574-2

SE-019-019-2H

REVISION A

JUNE 2, 1975

Chg. 2 8/15/75

Chg. 3 10/15/75

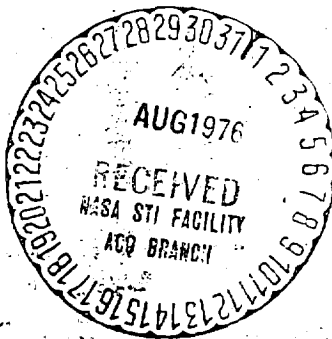
Chg. 4 3/10/76

Chg. 5 5/25/76

SHUTTLE MASTER VERIFICATION PLAN

VOLUME IV
(JSC-07700-10-MVP-04)

SOLID ROCKET BOOSTER VERIFICATION PLAN



(NASA-TM-X-74138) SHUTTLE MASTER
VERIFICATION PLAN. VOLUME 4: SOLID ROCKET
BOOSTER VERIFICATION PLAN, PRELIMINARY
DRAFT, REVISION A (NASA) 146 p

N76-76874

Unclas
00/98 48690

PREPARED BY:
SYSTEMS INTEGRATION BRANCH
SPACE SHUTTLE SYSTEMS DIVISION
SYSTEMS ANALYSIS AND INTEGRATION LABORATORY



CHANGE SHEET
FOR
SHUTTLE MASTER VERIFICATION PLAN
VOLUME IV - SOLID ROCKET BOOSTER VERIFICATION PLAN

CHANGE NO. 5

MSFC Configuration Control Board Directive No.

SB3-00-0546 (PCN 02111) dated 4-12-76

SB3-00-0568 (PCN 01268) dated 4-20-76

May 25, 1976

CHANGE INSTRUCTIONS

1. Remove the following listed pages and replace with the same numbered attached pages:

<u>Page</u>	<u>Page</u>
3-19 CCBD SB3-00-0546	iii CCBD SB3-00-0546
3-20	iv
3-25	v
3-26 CCBD SB3-00-0546	vi CCBD SB3-00-0568
3-27	
3-28 CCBD SB3-00-0546	
3-33	
3-34 CCBD SB3-00-0546	
5-9 CCBD SB3-00-0568	

NOTE: A black bar in the margin indicates the information that has changed.

2. Remove List of Effective Pages dated March 10, 1976.

Place List of Effective Pages dated May 25, 1976, under cover sheet.

3. Sign and date this page in the space provided below to show that the changes have been incorporated and file immediately behind LIST OF EFFECTIVE PAGES.

James Donald
Signature of person incorporating changes

6-22-76
Date

SHUTTLE MASTER VERIFICATION PLAN

Volume IV - Solid Rocket Booster Verification Plan

Revision A (Reference CCBD SB3-00-0187, dated 6/13/75)

LIST OF EFFECTIVE PAGES

May 25, 1976

The current status of all pages in this document is as shown below:

<u>Page No.</u>	<u>Change No.</u>	<u>CCBD No.</u>	<u>Date</u>
i-ii	Rev. A	SB3-00-0187	6/13/75
iii	5	SB3-00-0546	5/25/76
iv	4	SB3-00-0397	12/12/75
v	Rev. A	SB3-00-0187	6/13/75
vi	5	SB3-00-0568	5/25/76
vii	4	SB3-00-0397	12/12/75
1-1 - 3-1	Rev. A	SB3-00-0187	6/13/75
3-2	4	SB3-00-0391	12/12/75
3-3 - 3-6	Rev. A	SB3-00-0187	6/13/75
3-7	3	SB3-00-0321	10/16/75
3-8 - 3-14	Rev. A	SB3-00-0187	6/13/75
3-15	4	SB3-00-0391	12/12/75
3-16 - 3-18	Rev. A	SB3-00-0187	6/13/75
3-19	5	SB3-00-0546	5/25/76
3-20	Rev. A	SB3-00-0187	6/13/75
3-21	4	SB3-00-0397	12/12/75
3-22 - 3-23	Rev. A	SB3-00-0187	6/13/75
3-24	4	SB3-00-0397	12/12/75
3-25	Rev. A	SB3-00-0187	6/13/75
3-26	5	SB3-00-0546	5/25/76
3-27	Rev. A	SB3-00-0187	6/13/75
3-28	5	SB3-00-0546	5/25/76

CHANGE NO. 5

<u>Page No.</u>	<u>Change No.</u>	<u>CCBD No.</u>	<u>Date</u>
3-29	Rev. A	SB3-00-0187	6/13/75
3-30	2	SB3-00-0231	8/1/75
3-31 - 3-33	Rev. A	SB3-00-0187	6/13/75
3-34	5	SB3-00-0546	5/25/76
4-1	4	SB3-00-0397	12/12/75
4-2	Rev. A	SB3-00-0187	6/13/75
4-3	2	SB3-00-0231	8/1/75
4-4 - 4-6	Rev. A	SB3-00-0187	6/13/75
4-7	2	SB3-00-0231	8/1/75
4-8 - 4-9	Rev. A	SB3-00-0187	6/13/75
4-10	4	SB3-00-0397	12/12/75
4-11	Rev. A	SB3-00-0187	6/13/75
4-12	4	SB3-00-0397	12/12/75
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4-15	Rev. A	SB3-00-0187	6/13/75
4-16	4	SB3-00-0397	12/12/75
4-17	Rev. A	SB3-00-0187	6/13/75
4-18	4	SB3-00-0397	12/12/75
4-19 - 5-8	Rev. A	SB3-00-0187	6/13/75
5-9	5	SB3-00-0568	5/25/76
6-1	3	SB3-00-0321	10/16/75
6-2 - 7-2	Rev. A	SB3-00-0187	6/13/75
7-3	3	SB3-00-0321	10/16/75
8-1 - 8-2	Rev. A	SB3-00-0187	6/13/75

SPECIFICATION CHANGE NOTICE

DATE:

APRIL 6, 1976

No. 004

SUPERSEDING:

1. ECP ECH NUMBER: PRCBD S02111	2. PROGRAM - ITEM: SRB	3. SPEC. NUMBER: SE-019-019-2H REV. A
4. CONTRACT NUMBER: N/A	5. APPROVAL AUTHORITY/DATE: SB3-00-0546 4/12/76	FILE OPPOSITE REPLACE SPEC. SEE BLOCK 7 PAGE NO.
5. EFFECTIVITY: N/A		PCIN 02111

7. EFFECT OF CHANGE:

On page 3-19, add the following paragraph 3.5.4:

3.5.4 SRB PROJECT OFFICE RECORDING, REPORTING AND RECORDKEEPING RESPONSIBILITIES

SRB Project Office shall keep complete records, on a test or analysis basis, of the configuration of hardware, software and documentation used to conduct the test or analysis.

A listing (or reference to a listing) of the configuration of hardware, software and documentation, for both the flight and ground systems utilized during each test or analysis shall be included as an appendix to the verification test or analysis reports. Copies of each of the hardware utilization list, computer programs and test documentation for both flight and ground systems shall be maintained by the SRB Project Office until released by the Shuttle Program Office, or responsible Project Office.

On page 3-26, Exhibit 3.5.2-2, subparagraph DEVELOPMENT TEST/ANALYSIS REPORTS, add:

A listing (or reference to a listing) of the configuration of hardware, software and documentation, for both the flight and ground systems utilized during each test or analysis shall be included as an appendix to the test or analysis reports.

On page 3-27, Exhibit 3.5.2-2, subparagraph CERTIFICATION TEST/ANALYSIS REPORTS, add:

A listing (or reference to a listing) of the configuration of hardware, software and documentation, for both the flight and ground systems utilized during each test or analysis shall be included as an appendix to the test or analysis reports.

On page 3-33, Exhibit 3.5.2-2, subparagraph SE TEST SUMMARY REPORT, add:

A listing (or reference to a listing) of the configuration of hardware, software and documentation, for both the flight and ground systems utilized during each test or analysis shall be included as an appendix to the test or analysis reports.

3-25-76
7000

SE-019-019-2H
Change No. 4

CHANGE SHEET
FOR
SHUTTLE MASTER VERIFICATION PLAN
VOLUME IV - SOLID ROCKET BOOSTER VERIFICATION PLAN
CHANGE NO. 4

MSFC Configuration Control Board Directive No.
SB3-00-0391 (PCN 01747) dated 12-12-75 and
SB3-00-0397 (PCN 02255) dated 12-12-75

March 10, 1976

CHANGE INSTRUCTIONS

1. Remove the following listed pages and replace with the same numbered attached pages:

<u>Page</u>		<u>Page</u>	
3-1		iii	
3-2	CCBD SB3-00-0391	iv	CCBD SB3-00-0397
3-15	CCBD SB3-00-0391	vii	CCBD SB3-00-0397
3-16			
3-21	CCBD SB3-00-0397		
3-22			
3-23			
3-24	CCBD SB3-00-0397		
3-27			
3-28	CCBD SB3-00-0397		
4-1	CCBD SB3-00-0397		

NOTE: A black bar in the margin indicates the information that has changed.

Delete the following sheets from the document.

4-2 - 4-4 CCBD SB3-00-0397
4-13 - 4-18 CCBD SB3-00-0397
4-21 - 4-27 CCBD SB3-00-0397
4-30 - 4-36 CCBD SB3-00-0397
4-39 - 4-43 CCBD SB3-00-0397
4-46 - 4-50 CCBD SB3-00-0397
4-53 - 4-60 CCBD SB3-00-0397
viii CCBD SB3-00-0397

Add the following renumbered sheets: 3-29 - 3-34, 4-2 - 4-19

2. Place LIST OF EFFECTIVE PAGES dated March 10, 1976 under cover sheet.

3. Sign and date this page in the space provided below to show that the changes have been incorporated and file immediately behind LIST OF EFFECTIVE PAGES.

Jayne Martin
Signature of person incorporating changes

4/22/76
Date

SHUTTLE MASTER VERIFICATION PLAN

Volume IV - Solid Rocket Booster Verification Plan

Revision A (Reference CCBD SB3-00-0187, dated 6/13/75)

LIST OF EFFECTIVE PAGES

March 10, 1976

The current status of all pages in this document is as shown below:

<u>Page No.</u>	<u>Change No.</u>	<u>CCBD No.</u>	<u>Date</u>
i-iii	Rev. A	SB3-00-0187	6/13/75
iv	4	SB3-00-0397	12/12/75
v-vi	Rev. A	SB3-00-0187	6/13/75
vii	4	SB3-00-0397	12/12/75
1-1 - 2-2	Rev. A	SB3-00-0187	6/13/75
3-1	Rev. A	SB3-00-0187	6/13/75
3-2	4	SB3-00-0391	12/12/75
3-3 - 3-6	Rev. A	SB3-00-0187	6/13/75
3-7	3	SB3-00-0321	10/16/75
3-8 - 3-14	Rev. A	SB3-00-0187	6/13/75
3-15	4	SB3-00-0391	12/12/75
3-16 - 3-20	Rev. A	SB3-00-0187	6/13/75
3-21	4	SB3-00-0397	12/12/75
3-22 - 3-23	Rev. A	SB3-00-0187	6/13/75
3-24	4	SB3-00-0397	12/12/75
3-25 - 3-27	Rev. A	SB3-00-0187	6/13/75
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3-30	2	SB3-00-0231	8/1/75
3-31 - 3-34	Rev. A	SB3-00-0187	6/13/75
4-1	4	SB3-00-0397	12/12/75
4-2	Rev. A	SB3-00-0187	6/13/75
4-3	2	SB3-00-0231	8/1/75
4-4 - 4-6	Rev. A	SB3-00-0187	6/13/75
4-7	2	SB3-00-0231	8/1/75
4-8 - 4-9	Rev. A	SB3-00-0187	6/13/75
4-10	4	SB3-00-0397	12/12/75
4-11	Rev. A	SB3-00-0187	6/13/75
4-12	4	SB3-00-0397	12/12/75
4-13	Rev. A	SB3-00-0187	6/13/75
4-14	4	SB3-00-0397	12/12/75
4-15	Rev. A	SB3-00-0187	6/13/75
4-16	4	SB3-00-0397	12/12/75
4-17	Rev. A	SB3-00-0187	6/13/75
4-18	4	SB3-00-0397	12/12/75
4-19	Rev. A	SB3-00-0187	6/13/75

Change No. -

10-20-75

CHANGE SHEET
FOR
SHUTTLE MASTER VERIFICATION PLAN
VOLUME IV - SOLID ROCKET BOOSTER VERIFICATION PLAN
CHANGE NO. 3

MSFC Configuration Control Board Directive No. SB3-00-0321, dated 10-16-75

October 15, 1975

CHANGE INSTRUCTIONS

1. Remove the following listed pages and replace with the same numbered attached pages:

Page

3-7

6-1

7-3

NOTE: A black bar in the margin indicates the information that has changed.

2. Place LIST OF EFFECTIVE PAGES dated October 15, 1975 under cover sheet.
3. Sign and date this page in the space provided below to show that the changes have been incorporated and file immediately behind LIST OF EFFECTIVE PAGES.

Carolyn Brazelton

Signature of person incorporating changes

Dec 12, 1975

Date

SHUTTLE MASTER VERIFICATION PLAN

Volume IV - Solid Rocket Booster Verification Plan

(Revision A (Reference CCBD SB3-00-0187, dated 6/13/75))

LIST OF EFFECTIVE PAGES

October 15, 1975

The current status of all pages in this document is as shown below:

<u>Page No.</u>	<u>Change No.</u>	<u>CCBD No.</u>	<u>Date</u>
1-3-28	Rev. A	SB3-00-0187	6/13/75
3-7	3	SB3-00-0321	10/16/75
3-29	2	SB3-00-0231	8/1/75
3-30 - 4-5	Rev. A	SB3-00-0187	6/13/75
4-6	2	SB3-00-0226	7/22/75
4-7 - 4-9	Rev. A	SB3-00-0187	6/13/75
4-10	2	SB3-00-0226	7/22/75
4-11 - 4-36	Rev. A	SB3-00-0187	6/13/75
4-37	2	SB3-00-0226	7/22/75
4-38 - 8-2	Rev. A	SB3-00-0187	6/13/75
6-1	3	SB3-00-0321	10/16/75
7-3	3	SB3-00-0321	10/16/75

Change No. 3

(10-12-75)

SE-019-019-2H
Change No. 2

CHANGE SHEET
FOR
SHUTTLE MASTER VERIFICATION PLAN
VOLUME IV - SOLID ROCKET BOOSTER VERIFICATION PLAN

CHANGE NO. 2

MSFC Configuration Control Board Directive No. SB3-00-0231, dated 8/1/75, and SB3-00-0226, dated 7/22/75.

August 15, 1975

CHANGE INSTRUCTIONS

1. Remove the following listed pages and replace with the same numbered attached pages:

Page

3-29

4-6

4-10

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NOTE: A black bar in the margin indicates the information that has changed.

2. Place LIST OF EFFECTIVE PAGES dated August 15, 1975 under cover sheet.
3. Sign and date this page in the space provided below to show that the changes have been incorporated and file immediately behind LIST OF EFFECTIVE PAGES.

Signature of person incorporating changes

Date

SHUTTLE MASTER VERIFICATION PLAN
Volume IV - Solid Rocket Booster Verification Plan
(Revision A (Reference CCBD SB3-00-0187, dated 6/13/75))

LIST OF EFFECTIVE PAGES

August 15, 1975

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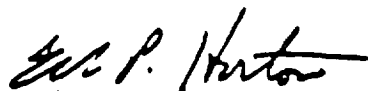
<u>Page No.</u>	<u>Change No.</u>	<u>CCBD No.</u>	<u>Date</u>
i - 3-28	Rev. A	SB3-00-0187	6/13/75
3-29	2	SB3-00-0231	8/1/75
3-30 - 4-5	Rev. A	SB3-00-0187	6/13/75
4-6	2	SB3-00-0226	7/22/75
4-7 - 4-9	Rev. A	SB3-00-0187	6/13/75
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4-37	2	SB3-00-0226	7/22/75
4-38 - 8-2	Rev. A	SB3-00-0187	6/13/75

Change No. 2

NOTICE—When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

APPLICATION		PART NO.	MF	REVISIONS			
NEXT ASSY	USED ON			SYM	DESCRIPTION	DATE	APPROVAL

APPROVED:

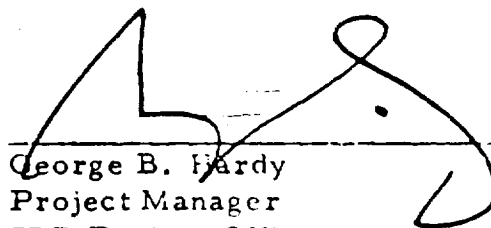


W. P. Horton

Chief Engineer

SRB Engineering Office

APPROVED:

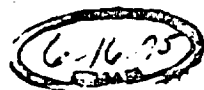


George B. Hardy

Project Manager

SRB Project Office

CCBD SB3-00-0187

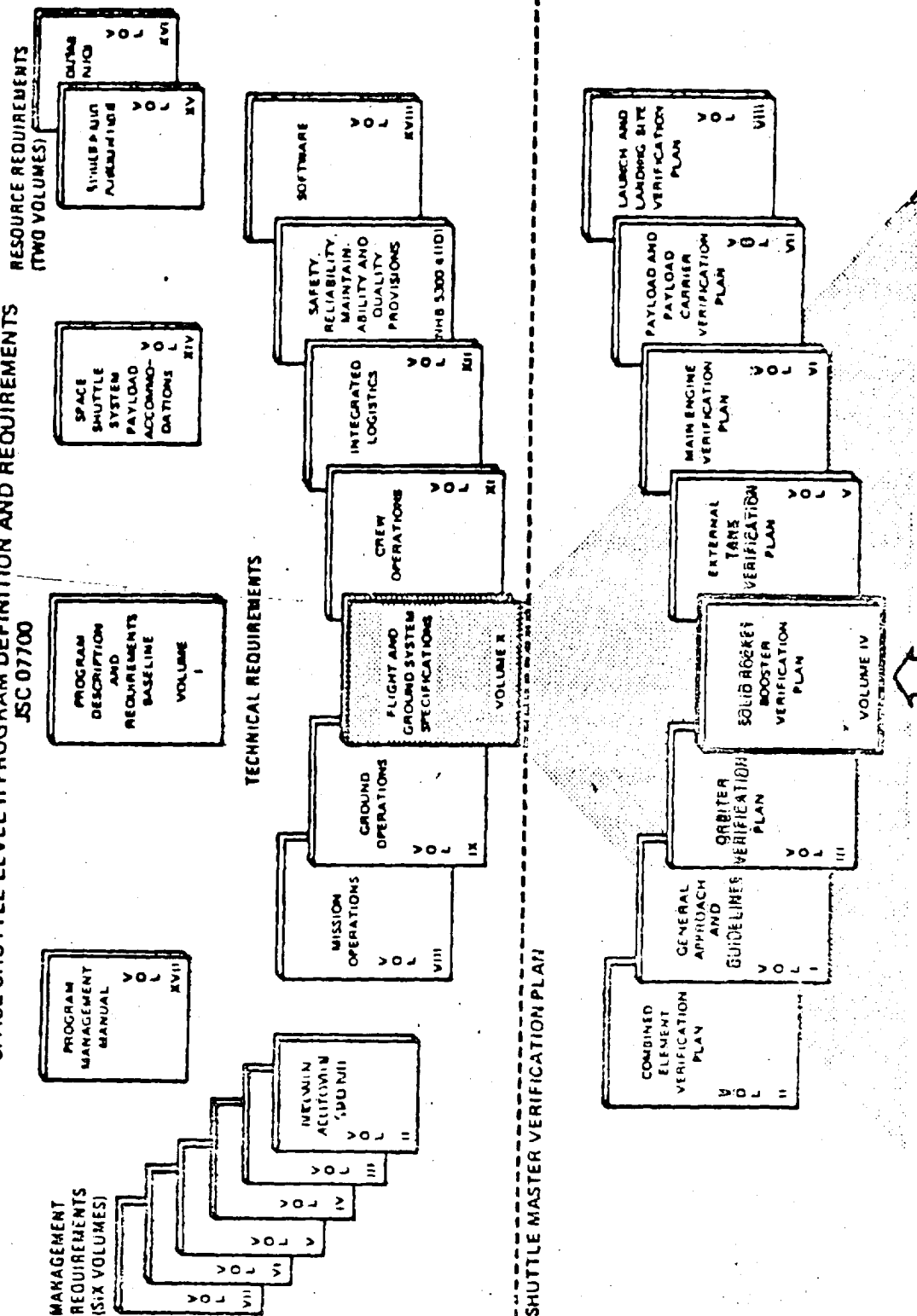


UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON: FRACTIONS DECIMALS ANGLES	ORIGINAL DATE OF DRAWING		Shuttle Master Verification Plan - Volume IV (JSC 07700-10-MVP-04) Solid Rocket Booster Verification Plan	GEORGE C. MARSHALL SPACE FLIGHT CENTER NATIONAL AERONAUTICS AND SPACE ADMINISTRATION HUNTSVILLE, ALABAMA
	DRAFTSMAN	CHECKER		
MATERIAL	TRACER	CHECKER	SCALE	DWG SIZE A
HEAT TREATMENT	ENGINEER	ENGINEER		
FINAL PROTECTIVE FINISH	APPROVED W. a. Huff FL41/W. Huff		UNIT WT 12	SE-019-019-1 SHEET 07

REVISIONS

REV LTR	CHANGE NO.	DESCRIPTION	DATE
A	1	Baseline Issue (reference CCBD SB3-00-0003, dated 4/22/74). Complete revision of baseline issue (reference CCBD SB3-00-0187, dated 6/13/75).	3/15/75 6/2/75

SPACE SHUTTLE LEVEL II PROGRAM DEFINITION AND REQUIREMENTS JSC 07700



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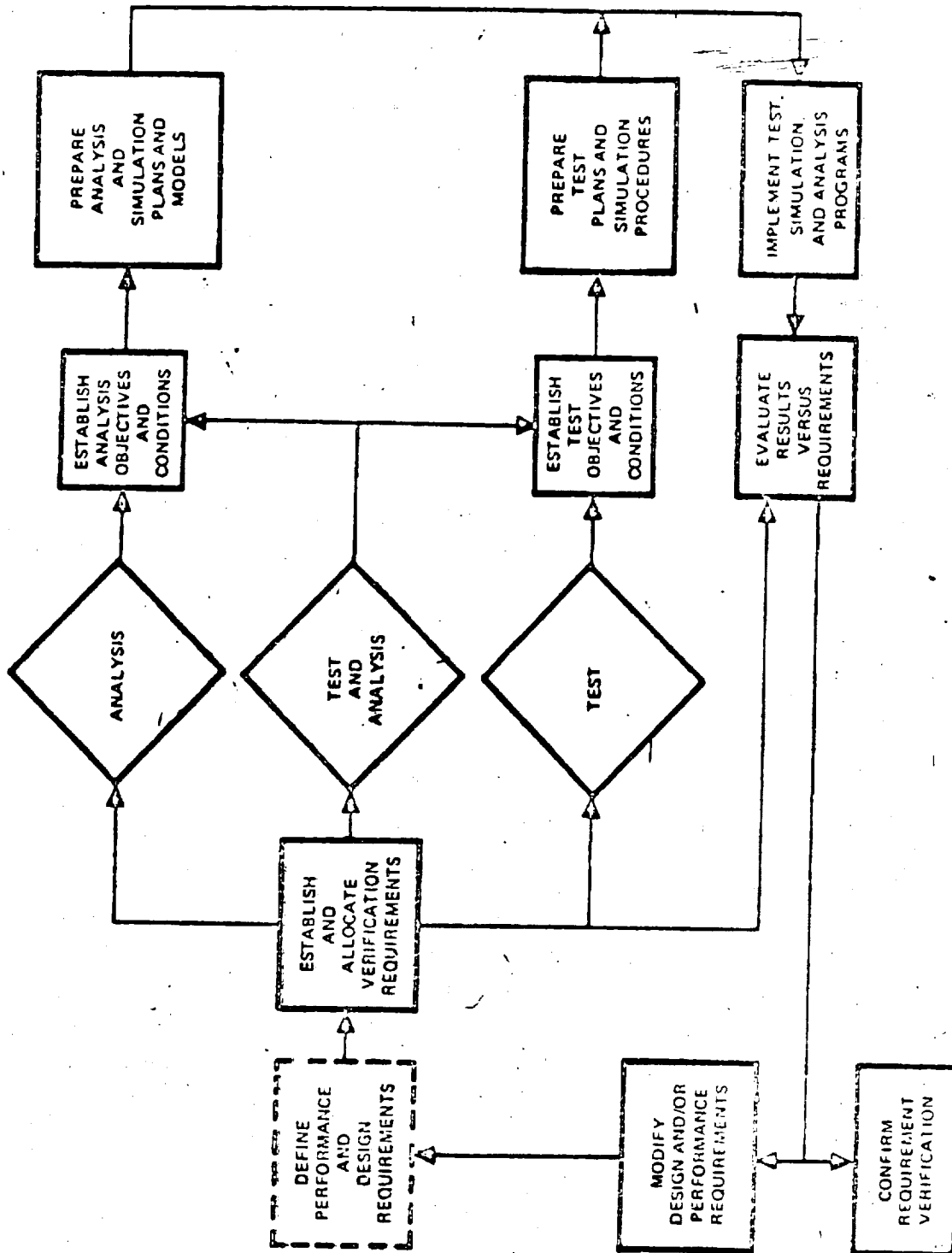
1.0 INTRODUCTION

1.1 PURPOSE. This volume defines the verification program for the Solid Rocket Booster (SRB) element of the Space Shuttle System. It is prepared in compliance with the Level II requirement for a Solid Rocket Booster Verification Plan and is Volume IV of the total Shuttle Master Verification Plan (SMVP). It describes the requirements and approach for verifying the capability of the SRB to support the Space Shuttle System operations. It is the principal controlling document for Solid Rocket Booster verification activity.

1.2 SCOPE. The scope of this document includes the verification effort associated with (1) the SRB element, assemblies, subsystems, and components, (2) SRB ground support equipment (GSE) and test facilities, and (3) those element interfaces for which the SRB Project Office, Marshall Space Flight Center (MSFC), is responsible.

1.3 MASTER VERIFICATION PLAN OUTLINE. This document contains the SRB project level requirements to assure that SRB verification complies with Level II requirements and that verification is performed in the most cost effective manner. A summary of the verification process is presented as Figure 1.3-1. The document is organized to provide the definition and requirements for the SRB component, subsystem and element verification activities. The documentation required for the program is identified in paragraph 3.5 which describes the contents of each document and the related organizational responsibilities. The approach to SRB verification will be found in paragraph 4.1. This paragraph contains the element verification network, a description of each subsystem, and subsystem verification networks and matrices which provide a cross-reference to the Contract End Item Specification for the type of verification to be performed to satisfy the specification requirements during each phase of the program. Element verification, including final manufacturing assembly and checkout, prelaunch checkout, flight and post-flight activities are described in paragraph 5.0. The major ground tests supporting the various phases of verification are also identified in this paragraph. Finally, the verification of the SRB ground support equipment is described in paragraph 6.0.

1.4 VERIFICATION PROGRAM OBJECTIVES. Verification is the process of planning and implementing a program to demonstrate that the Shuttle System Solid Rocket Booster meets all design/performance requirements. The objectives of the SRB verification program are (1) support to the development of the SRB design; (2) certification that the SRB design meets performance requirements; (3) acceptance test and checkout to assure that deliverable SRB hardware is manufactured to the certified design; (4) verification that SRB hardware, when integrated with other Shuttle elements, meets design/performance requirements; (5) verification by flight and post flight analyses that the SRB satisfies operational requirements; and (6) verification that SRB ground



VERIFICATION PROCESS FLOW

FIGURE 1.3-1

support equipment and test facilities meet design/performance requirements.

The certification of the SRB will be based upon verification of all SRB requirements which are identified by the SRB Contract End Item Specification Part I (CP013M00000A). Final declaration of the SRB design integrity will be the Certificate of Flight Readiness (COFR).

1.5 REVISION. This document will be revised as required, cognizant of program maturation, to reflect changes resulting from updates to the Contract End Item Specification and changes to Level II requirements. All proposed changes to this document shall be submitted in accordance with MSFC Configuration Management Procedures.

2.0 APPLICABLE DOCUMENTS - The following documents, of the applicable revision, form a part of this document to the extent specified herein. In the event of conflict between documents referenced and the contents of this document, the order of precedence shall be as follows:

1. SE-019-019-2H
(JSC-07700-10-MVP-04) Shuttle Master Verification Plan, Volume IV, Solid Rocket Booster Verification Plan
2. JSC-07700-10-MVP-01 Shuttle Master Verification Plan, Volume I, General Approach and Guidelines.
3. JSC-07700-10-MVP-02 Shuttle Master Verification Plan, Volume II, Combined Element Verification Plan.
4. CP013M00000A Contract End Item Specification, Solid Rocket Booster (SRB)
5. Other Applicable Specifications and Standards.

2.1 SPECIFICATIONS.

NASA (National Aeronautics and Space Administration)

JSC SE-R-0006	General Specification, NASA JSC Requirements for Materials and Processes
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2.2 STANDARDS.

Military

MIL-STD-810B	Environmental Test Methods for Aerospace and Ground Equipment
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2.3 PUBLICATIONS

NASA

NHB 5300.4 (1D-1)	Safety, Reliability, Maintainability and Quality Provisions for the Space Shuttle Program.
JSC-07700-10-MVP-10	Shuttle System MVP, Volume X, Master Flight Assignment Document

JSC-SW-E-0002

Space Shuttle Ground Support
Equipment, General Design
Requirements

MSFC SE-020-009-2H

Space Shuttle, Solid Rocket
Booster (SRB) Materials Control
Plan

MMI 8080.5

Policy for Qualification of Flight
Hardware and Ground Support
Equipment, June 1969.

16A00100A

SRB EMC Control Plan

2.4 DRAWINGS

NASA

85M03936B

EEE Parts Selection and Applica-
tion Guidelines for the Space
Shuttle External Tanks and Solid
Rocket Booster (ET and SRB)

3.0 VERIFICATION PROGRAM. The SRB Verification program will incrementally validate that requirements established in the SRB CEI Specification have been met.

3.1 VERIFICATION PHASES. Six phases of verification activities - development, certification, acceptance, pre-flight, flight, and post-flight - will ensure a fully certified SRB vehicle. Verification in each phase will be accomplished by the methods of test and/or analysis.

3.2 VERIFICATION METHODS. Testing will be the preferred method of verification on the SRB program. In the event that testing is too complicated or costly, analysis may be substituted.

3.2.1 Analysis. Analysis will be used when it can be shown by accepted analytical techniques that the hardware item will meet design and performance requirements.

On the basis of cost considerations, analysis by the method of similarity will be preferred to other types of analysis. Similarity will be used in lieu of tests where it can be shown that an article is similar or identical in design, manufacturing processes, and quality control procedures to another article that has been previously certified to equivalent or more stringent criteria; and that the article has been fabricated by the same manufacturer using the identical processes, materials, and quality control procedures.

3.2.2 Test. Tests will be conducted to verify that a design and/or actual item of hardware is capable of performing its required operational functions in the known or anticipated environmental conditions. Development tests will be conducted to provide data to substantiate analysis, to verify design assumptions, to provide confidence that a design will meet certification requirements, and/or to provide data to certify design by analysis. Certification testing will be conducted to subject components and assemblies to specific environmental conditions, at stress levels and durations greater than those anticipated during flight, to demonstrate that design and performance requirements can be realized. To the maximum degree practical, uniform test criteria will be established for all items to be used in the same or a similar ground or flight environment. Acceptance testing and/or checkout will be performed on each component, subsystem, and integrated system to verify that the flight hardware meets the design and/or performance requirements within prescribed limits.

Demonstration will be the test method for design and/or hardware verification which do not have specific parameters identified. An example of a requirement that will be verified by demonstration is transportability. Inspections performed in accordance with an approved inspection plan will be the test method for physical characteristics and interface requirements. Major emphasis will be placed on accomplishing these verification inspections in conjunction with Configuration Inspections.

3.3 VERIFICATION PROGRAM POLICIES. The following policies will be used to direct the SRB verification program. These policies comply with the requirements as stated in the Shuttle Master Verification Plan, Vol. I.

3.3.1 Integration of Results and Data from Test Activities. Component, subsystem, and integrated element testing will be planned to support the SRB and Shuttle System development and verification. All test activities from development through vertical flight will be directed toward satisfying operational requirements of the Shuttle Program.

Maximum usage of all test and/or analysis data will be made in order to: 1) develop and standardize formal checkout procedures, 2) establish performance trends, 3) support maintenance planning, and 4) assist in the resolution of anomalies. All verification data will be maintained.

Testing which uses Computer systems as a portion of the test support shall utilize the Orbiter data processing system where such use will avoid duplicate or excessive ground support computer systems.

3.3.2 Acceptance Criteria and Tolerance Bands. Pass-fail criteria or acceptance tolerance bands based on design requirements will be specified for all tests. Acceptance tolerance bands at the manufacturer's component or subsystem level will be based on allowable operational tolerance bands. These operational tolerance bands will be progressively adjusted/normalized at the upstream acceptance points to allow for tolerance buildup experienced during subsystem and element acceptance checkout.

The tolerance band for a given specification value will include instrumentation accuracy; facility and support equipment stimuli tolerance; test specimen tolerance stack-up or expected variation from specimen to specimen; external environment (pressure, temperature, humidity, etc.); test influence variations; and component aging. The root sum square (RSS) method will be used to combine tolerance methods. Where the RSS method is not appropriate for a specific situation, other statistical approaches that consider all of the factors affecting system accuracy may be used if specified in the appropriate test plan. As a general guideline, the tolerance limits will:

- a. For testing, be as wide as possible to meet the test objective and minimize the accuracy requirement of the GSE.
- b. In test and checkout, be equal to or greater than factory limits.
- c. In test and checkout, be equal to or less than mission limits.

3.3.3 Hazardous Operations.

3.3.3.1 Failure Mode Effect Analysis (FMEA). The verification program will confirm that hazards identified by FMEA and by other studies such as hazard analysis and sneak circuit analysis have been eliminated by design changes or reduced to an acceptable level through the use of appropriate safety devices, warning devices, or special procedures.

3.3.3.2 Safety.

- a. Handling and test operating procedures will contain identification of hazardous operations with words "caution" or "warning" prior to beginning of hazardous steps and a statement advising when said series of hazardous steps have been completed.
- b. Emergency and shutdown procedures to prevent injury to personnel and/or prevent damage to hardware will be included in all test procedures.

3.3.3.3 Operational Readiness Inspection. An Operational Readiness Inspection (ORI) will be performed prior to performing any operation or test which (a) is potentially hazardous to personnel or hardware, (b) has high risks in terms of program importance, or (c) involves test hardware, facilities, equipment or effort having high dollar value. The ORI shall include a safety assessment of facilities, equipment, test articles, operational procedures and personnel capabilities.

3.4 SRB VERIFICATION PHASES

3.4.1 Development Phase.

3.4.1.1 General. During the development phase program, the SRB subsystem managers, under the direction of the SRB project office, will be responsible for the implementation and control of design evaluation and/or data gathering activities to select and prove the feasibility of the design approach. These activities will be conducted with minimum rigors and controls by various MSFC design/test laboratories and/or designated contractor hardware developers, to provide an engineering data base. The data base will support manufacturing processes, quality control procedures, operational hardware design, production, verification, maintenance, and checkout activities. The data base will also be used to demonstrate to a desired confidence level (1) that the selected configuration will satisfy combined performance requirements under ambient and/or selected environmental conditions, and (2) that the established manufacturing processes and quality control procedures will produce acceptable hardware which will accomplish mission objectives.

Development activities will include such tests as materials and processes, design feasibility, breadboard, and wind tunnel. Development tests will determine failure modes and safety factors. Certification can be performed during the development phase only if predeclared and provided that the requirements stated in Paragraph 3.4.2.2.1 are met.

3.4.1.2 Development Requirements. Requirements for the development program will include but not be limited to the following:

3.4.1.2.1 Representative Hardware. Development test hardware will be representative of, but not necessarily identical to, certification hardware.

3.4.1.2.2 Testing for Certification. Each SRB subsystem manager will determine when the design has progressed to the degree that testing for certification may begin. Requests to perform tests for certification will be approved by the subsystem manager.

3.4.1.2.3 Test Records. Development tests will not be subject to the rigors and controls associated with certification and acceptance/checkout programs. However, adequate records of development test hardware configuration, test results, and other pertinent data will be maintained so that this information can be made available to supplement other portions of the verification program as required.

3.4.1.2.4 Software Integration. Early software integration will be a key program goal. The Electrical and Instrumentation Verification Test Program will be utilized to develop and verify the ground support equipment software and checkout procedures required for final manufacturing assembly checkout of the flight equipment.

3.4.1.2.5 Maintenance Requirements. Hardware maintenance and/or replacement requirements will be refined in the development test program.

3.4.1.2.6 Downstream Test Procedures. Experience gained during the development phase will be utilized to develop certification and acceptance test procedures.

3.4.1.2.7 Nondestructive Testing. New nondestructive testing techniques will be verified during the development test program.

3.4.1.2.8 EMC Analyses. Electromagnetic compatibility (EMC) analyses will be performed on components and subsystems to support hardware design and installation selection during the development phase. EMC testing should be minimized and limited to that necessary to reduce the risk of finding significant problems in the final EMC verification during vehicle integrated testing.

3.4.1.2.9 Sensor Locations. Determination of the adequacy of sensor locations for development flight instrumentation and operational flight instrumentation will begin during the development phase.

3.4.1.2.10 Use of Analysis. All development requirements will be satisfied by the maximum use of test, supported by analysis.

3.4.1.2.11 Overstress and Fail-Safe Testing. If applicable, overstress and fail-safe testing will be conducted utilizing development test hardware after completion of all other development tests on the item(s) of hardware to be overstress or fail-safe tested.

3.4.1.2.12 Tolerance Buildups. Development tests will be designed to determine the effects of tolerance buildups and design parameter drift.

3.4.1.2.13 Off-Limit Testing. As a general guideline, off-limit testing will not be conducted. However, off-limit testing will be considered:

- a. When design margins are relatively small with respect to off-nominal abort conditions.
- b. When uncertainty exists in the definition of the design criteria.
- c. When single-point failure modes exist.
- d. When failure mode analysis indicates that a credible probability of associated hardware failures will create an off-limit condition.

Testing of this nature must have prior approval by the SRB project office and must consider preservation of certification hardware.

3.4.1.2.14 Material Compatibility. Material compatibility will be verified against NASA certified data. Where new materials (including fluids and non-metallics) are to be used, or existing materials are to be used under new conditions, or where existing data cannot be traced to accepted materials, testing will be performed at the material level to establish material property values. Excluding the SRM, subsystem materials selection and verification will follow the procedures contained in MSFC SE-020-009-2H, SRB Materials Control Plan. Selection of materials used on the SRM subsystem will be in accordance with JSC SE-R-0006, JSC Requirements for Materials and Processes.

3.4.1.2.15 Structural Tests. Structural tests will be performed to determine the ability of a structure to withstand predicted static and dynamic forces which may be encountered in assembly, storage, transportation, handling, testing, flight, and recovery. Structural tests will be performed on the largest practicable assemblies of structural hardware.

3.4.1.2.16 Interface Compatibility. Compatibility tests will be conducted to arrive at the proper physical, functional, and operational interfaces of mating hardware.

3.4.2 Certification Phase.

3.4.2.1 General. Certification consists of all qualification tests, major ground tests and other tests and analysis required to determine that the design of hardware and software from the component through the subsystem level meets requirements.

Qualification tests will be conducted as part of the certification program to demonstrate that design and performance requirements can be realized under specific environmental conditions. All SRB flight hardware, software, and selected CSE will be certified. Certification requirements will be based on verifying all performance and design requirements which are imposed on each component and subsystem.

A Certificate of Qualification (COQ) will be prepared by the responsible development organization for each item requiring certification using MSFC Form 511 or an equivalent form. The COQ's will be forwarded to the MSFC Reliability and Quality Assurance Office (R&QA) for approval and file maintenance.

MSFC Management Instruction (MMI) 8080.5, Policy for Qualification of Flight hardware and Ground Support Equipment, defines the policies, responsibilities, and administration of qualification activities which, as applicable, will be adhered to during the certification activities.

The end product of certification is the establishment of a Certified Hardware List (CHL). The MSFC R&QA Office is responsible for establishing and maintaining the CHL for all SRB certified items.

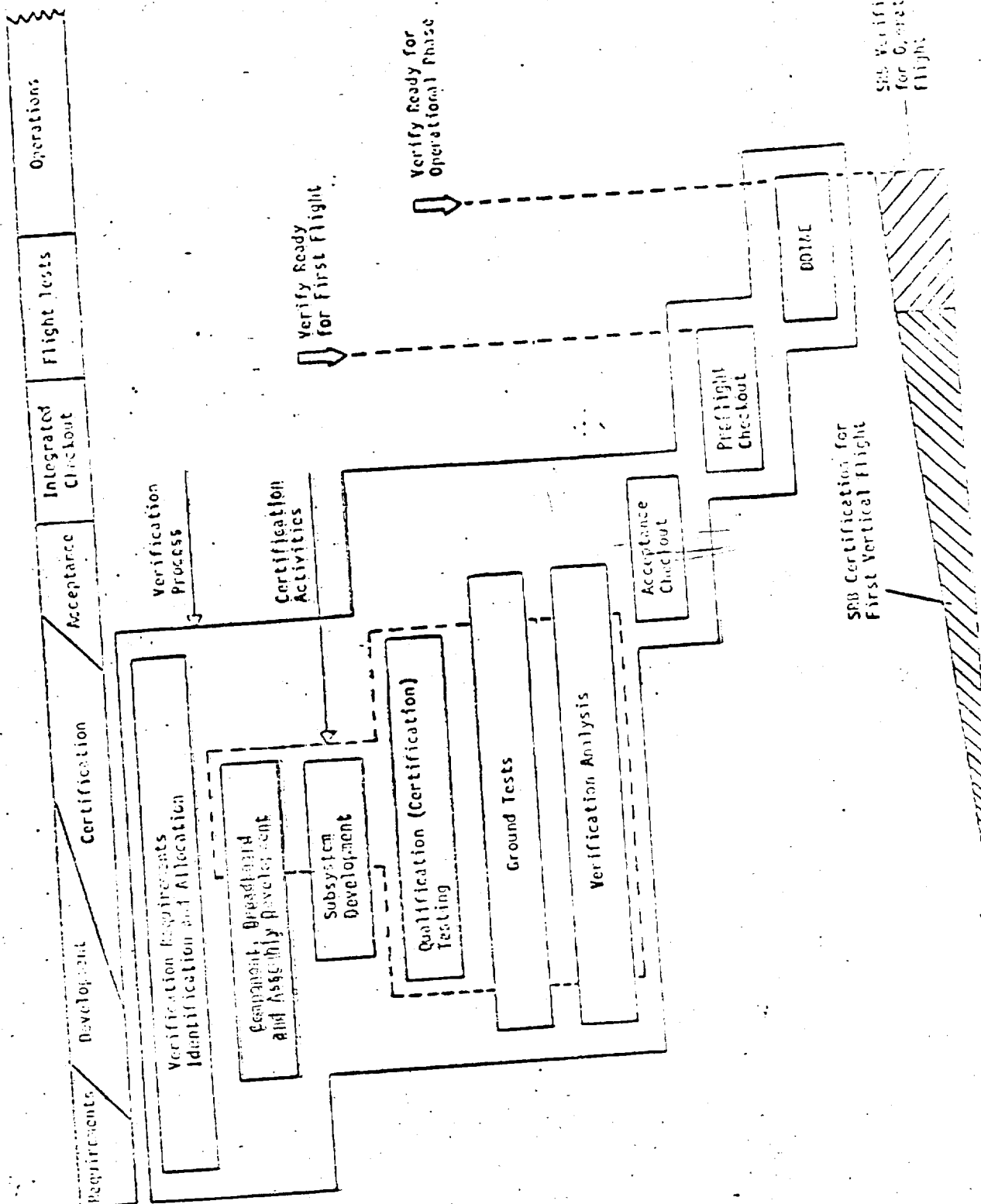
Figure 3.4.2.1-1 shows how the SRB certification activities fit into the overall verification program.

3.4.2.1.1 Piece Parts. Electrical, electronic, and electro-mechanical (EEE) parts are certified and/or selected through a separate plan using NASA document 85M03936B and are not a part of these certification guidelines. Mechanical piece parts shall be selected in accordance with TBD.

3.4.2.2 Certification Requirements.

3.4.2.2.1 Development Testing. Certification requirements may be satisfied during development testing in those cases where the following criteria are met:

- a. Prior approval of the MSFC SRB Project Office is obtained.
- b. The intent to use the test for certification is declared prior to the test.
- c. Production hardware configuration is used or MSFC SRB Project Office approval is obtained for any differences in configuration.



OVERALL VERIFICATION PROGRAM
FIGURE 3.4.2.1-1

- d. Test equipment and facilities have been certified.
- e. Quality controls are maintained during the test.
- f. Documentation delineating test requirements, procedures, and pass-fail criteria has been approved by the MSFC SRB Project Office.
- g. Functional tests are performed on the test hardware prior to and subsequent to the certification test. The functional tests will conform to acceptance test criteria.
- h. A final report is submitted to the MSFC SRB Project Office describing configuration and significant events, including failures and test results.

3.4.2.2.2 Redundancy. Where redundancy within a component or assembly is required, certification will assure that the redundancy capability is verified.

3.4.2.2.3 Mature Designs. Mature (off-the-shelf) hardware will require full certification. The major part of this certification, and in some cases the full certification, will be accomplished by analysis. Hardware capability will be evaluated and documented utilizing a matrix which will compare Shuttle requirements with the requirements met by the mature hardware. Areas such as configuration, performance, and environment will be considered in the matrix. When mature hardware meets Shuttle requirements, the hardware will be considered fully certified. Where Shuttle environments are more stringent, or where previous certification did not include all Shuttle environments, or where minor modifications have been made, additional certification will be performed on the design modifications and/or more stringent or additional environments only.

3.4.2.2.4 Pre-Certification Acceptance. Full acceptance testing will be conducted on all test specimens prior to qualification tests. With prior MSFC SRB Project Office approval, portions of the acceptance test may be combined with the qualification test and made to be a part thereof.

3.4.2.2.5 Certification Limits. Certification will be structured to verify the full range of the design requirements, except as indicated under life certification guidelines.

3.4.2.2.6 Test Assembly Level. Testing will be conducted at the level of assembly which is most cost effective for fulfilling certification requirements. Qualification of an item by test of a higher assembly will limit its usage to that assembly unless complete environmental data is recorded for the particular item within the higher assembly. Qualification of an item by test of a higher assembly or module

is acceptable provided the item being qualified is subjected to stress levels and time durations during the higher assembly test which are equal to or higher than the environmental qualification levels and durations specified for the item in the proposed application. Interactions between the various components and subsystems must be considered and evaluated when individual hardware items are qualified as part of a higher assembly test.

3.4.2.2.7 Number of Test Specimens.

- a. Each MSFC subsystem manager is responsible for determining the number of test specimens required for certification with concurrence from the responsible MSFC design group.
- b. The number of specimens selected shall be sufficient to yield a significant level of engineering confidence. Normally, there shall be a minimum of two samples, each undergoing all tests in the qualification series. Consideration may be given to using one sample when dealing with very large or extremely expensive components.
- c. The number will be that which is required to demonstrate the design in applied environments and which is sufficient to certify the design, including satisfaction of the life certification requirements given in paragraph 3.4.2.2.11. Every effort will be made to keep the number of specimens to a minimum.
- d. Sample sizes will not normally be selected to statistically demonstrate hardware reliability.

3.4.2.2.8 Configuration. Qualification test hardware will be of the same configuration as the flight hardware and fabricated by the same manufacturer using identical processes, materials, and quality control procedures, unless differences are formally approved and adequately documented. Hardware will be selected randomly from a normal production run. If first production items are selected, then all subsequent production items shall be produced identically to the selected test items.

3.4.2.2.9 Specimen Installation. When flight hardware will potentially be affected by mounting, the qualification test hardware will be mounted in a manner simulating the actual installation in the flight vehicle.

3.4.2.2.10 Environmental Conditions. The SRB environmental requirements will be defined by the SRB CEI Specification CP013-M00000A.

Specific environmental criteria, i. e., thermal, vibration, acoustic, etc., not defined in the CEI Specification, but required to satisfy certification requirements, will be derived from the data contained in the CEI specification. The test requirements, tolerances and methods identified in the CEI Specification will apply. The test methods defined in MIL-STD-810B, Environmental Test Methods, will be used if the CEI Specification does not provide test methods for any specific certification requirement.

Environmental conditions which occur during transportation, handling, assembly, checkout, and storage and which exceed the certification criteria identified in the CEI Specification, will be factored into the certification program.

3.4.2.2.11 Life Certification. Environmental and operational design life certification is a program requirement. The requirement must be individually specified for each component or assembly, considering its design, criticality and maintenance requirement. Life certification may be achieved by test, analysis, or a combination thereof. A test duration less than design life is acceptable for certification if a shorter duration is supported by analysis or reliable test experience. Except for the development flight hardware which will be certified for one mission cycle, these shorter duration life demonstrations will not be less than twenty normal mission cycles. A single mission cycle consists of the aggregate of acceptance, buildup and assembly, stacking, pre-launch checkout, flight/recovery, retrieval and refurbishment/turnaround activities.

3.4.2.2.12 Environmental Test Survival. If operational test hardware is not operating during an environmental certification test, a functional test will be performed on the test hardware after each such environmental exposure. The functional test will determine whether the test hardware is performing within specification tolerances.

3.4.2.2.13 Failure Reporting and Corrective Action. A failure or unsatisfactory condition encountered during qualification testing will require reporting and positive corrective action in accordance with NHB 5300.4 (1D-1).

3.4.2.2.14 Preservation of Test Hardware. Qualification test hardware will be preserved for recertification activities when determined to be cost effective. Hardware items subjected to qualification testing shall be so identified and shall not be utilized as flight hardware.

3.4.2.2.15 Compatibility with Fluids. All hardware coming in contact with fluid(s) will have certification of compatibility with the fluid(s).

3.4.2.2.16 Test Facilities and Equipment.

- a. Test facilities and equipment, including associated data acquisition and reduction equipment, will be suitably and properly configured for the purpose of the qualification test and will bear evidence of valid and current calibration.
- b. GSE hardware items subjected to qualification testing will not be utilized in support of flight operations. Exceptions to this restriction may be allowed on a case-by-case basis by submission of a waiver to the cognizant Science and Engineering technical organization, provided:
 1. The qualification tests to which the item was subjected were not of a destructive nature.
 2. The operational time duration involved in the qualification tests has not been excessive to the extent that the remaining operational life of the item is inadequate for its intended usage.

3.4.2.2.17 Recertification. A Certificate of Qualification shall be withdrawn from an "APPROVED" status and placed in a "QUESTIONABLE" status pending hardware recertification when:

- a. Design or manufacturing process changes have been made which affect function or reliability.
- b. Inspection, test, mission change, or other data indicates that a more severe environment or operating condition exists than that for which the hardware was originally tested.
- c. The manufacturing source is changed.
- d. Changes are made in a specification, manufacturing process, or procurement source for any fluids or other materials used in processing or operating the hardware.
- e. Significant component failures or anomalies occur during repeat qualification testing or during vehicle/stage checkout.
- f. Recurrent failures occur under circumstances not covered in paragraphs a through e above, such as repetitive failures occurring during acceptance inspection and testing.

All such events shall be immediately reported to the cognizant Science and Engineering technical organization, and the COQ shall be retained

in a "QUESTIONABLE" status until engineering investigation or analysis indicates whether the COQ should be returned to the "APPROVED" status or changed to an "UNAPPROVED" status.

3.4.2.2.18 Electromagnetic Compatibility and Lightning Protection.

- a. Certification will be accomplished at the subsystem and/or individual equipment level to verify that the SRB will meet the EMC and lightning protection requirements of paragraph 3.3.5.1 in the SRB CEI Specification CP013M00000A.
- b. Final EMC verification will be performed during the element level integrated checkout by demonstrating compatibility in accordance with the SRB EMC plan 16A00100A.

3.4.2.2.19 Unattained Objectives. If any objectives are unattained upon completion of a qualification test, resolution by the MSFC SRB Project Office must be obtained before the test setup can be torn down. If any acceptance criteria controlled by a technical specification is not attained in a qualification test, a waiver from the MSFC SRB Project Office will be required.

3.4.3 Acceptance and Checkout

3.4.3.1 General. Acceptance of equipment will take place at the manufacturing source whenever practical. This will provide the inspection and testing rigor necessary to assure that functional pre-installation testing by the element contractor will be minimized. Consideration will be given to pre-installation acceptance tests or inspections on components prior to installation into the next higher level of assembly when any of the following circumstances exist:

- a. No previous acceptance test was completed.
- b. Acceptability cannot be verified by test of higher level of assembly.
- c. Significant time has elapsed since the last test. Such period shall be determined from the age/life characteristics of the component.
- d. The component, once installed in the next higher assembly, is difficult to remove and requires significant schedule time to replace.
- e. Prior failure history of the component indicates the need for pre-installation testing.
- f. The component, once installed in the next higher assembly, by its failure could damage the next higher assembly during test.

3.4.3.2 Acceptance Requirements

3.4.3.2.1 Controlled Environments. Test and pre-test storage environments and conditions will be controlled to prevent compromising the quality and/or reliability of the article.

3.4.3.2.2 Test Facilities and Equipment. Test facilities and equipment will be suitable for the purposes of the test and will bear evidence of valid calibration.

3.4.3.2.3. Tolerance Band. Each measured parameter for acceptance testing will have a specified tolerance band of acceptability.

3.4.3.2.4 Government Furnished Equipment. GFE will be acceptance tested by the supplier and, after installation in deliverable end item hardware, will again be tested and controlled as part of that end item.

3.4.3.2.5 Testing Control. Acceptance testing will require rigorous control, inspection and documentation to assure that the SRB element and applicable software, procedures and GSE meet the specified requirements of the Shuttle program.

3.4.3.2.6 Redundancy. In-process checkout of alternate and redundant functional paths and modes will be required on deliverable components. Checkout of alternate and redundant functional paths and modes will be required on deliverable components. This will be accomplished with minimum disturbance and at the most practical level of assembly.

3.4.3.2.7 Burn-In. Burn-in will be performed on hardware where aging is a factor to reduce early operational failures. Electronic piece parts normally fall into this category. The development flight equipment listed in paragraph 4.2.1 is not required to adhere to this paragraph.

3.4.3.2.8 Wear-In. Cycling tests will be performed on hardware where a wear-in period is required to assure proper seating or conditioning.

3.4.3.2.9 Environmental Testing. Environmental acceptance testing will be performed on selected hardware to screen out manufacturing defects, workmanship errors, and incipient failures not readily detectable by normal inspection techniques or through functional test.

3.4.3.2.10 Reacceptance. Reacceptance may be required whenever (1) the article or material does not meet the contract or contractor specifications requirements, or (2) the inspection or test performed is not in accordance with test specifications or inspection and test procedures, or (3) the hardware malfunctions, or (4) modifications, repairs, replacements, or rework of the article or material occur after the start of inspection or testing, or (5) the article or material is subject to drift or degradation during storage or handling (periodic intervals for reinspection or retest will be established), or (6) specified by the Material Review Board (retest will be limited by consideration of remaining useful life and operating time for certification).

Reacceptance will not always require a complete functional checkout of the subsystems involved. It may consist only of a verification of the disturbed interfaces and a functional demonstration of replaced line replaceable units (LRU).

3.4.3.2.11 Integrated Acceptance Checkout. Each SRB end item will be subjected to an integrated acceptance checkout after assembly. This test will be structured to demonstrate to the extent possible the satisfactory construction, operation, and performance of the item. This test will minimize the need for formal in-process or subsystem demonstrations during or following assembly or after any operation that would require reacceptance testing.

3.4.3.2.12 Use of Operational Signals. Tests of subsystems installed in the flight vehicle will use operational signals as stimuli insofar as possible.

3.4.3.2.13 Preceding Flight Data. Full utilization will be made of subsystem performance data from the preceding flight to verify system performance and minimize ground checkout requirements for the next flight.

3.4.3.2.14 Proof Testing. Proof testing will be accomplished as required to satisfy the fracture control requirements of the SRB CEI Specification.

3.4.3.2.15 Nondestructive Testing. Nondestructive test verification methods and procedures will be developed to support launch and turnaround operational requirements.

3.4.3.2.16 Acceptance Test Objectives. Objectives of each test to be performed will be clearly stated in the acceptance test procedure. Test objectives will be formulated from test requirements. General test objectives are as follows:

- a. Verify proper performance.
- b. Record component operational ranges and normal operating limits.
- c. Detect marginal operations.
- d. Note unique or unusual operating characteristics.
- e. Detect design, manufacturing, and/or quality problems.
- f. Provide test data for later use in analyzing component, subsystem, or element problems or degradation.
- g. Assure no handling damage has occurred.
- h. Verify component configuration exactly agrees with contractual requirements.

3.4.3.2.17 Reverification Criteria. The following minimum reverification criteria will apply during turnaround operations:

- a. Active and passive functional paths (FP) affected will be reverified if:
 - (1) A failure or an anomaly has occurred in the FP during the last flight.

- (2) The FP is scheduled for active use on the next flight and was not active on the last flight.
 - (3) The FP was (or may have been) disturbed since the last flight due to maintenance, servicing, or modification activities.
 - (4) The FP was completed (i. e. made/connected) since the last flight due to mating or modification activities.
 - (5) The FP was not used since exposure to a hostile flight environment and has not been shown to be insensitive to such environment by analysis or experience. During initial turnarounds, all FPs will be reverified. The number of FPs to be reverified will be reduced with time based on early experience.
 - (6) The FP is (or may be) needed on the next mission and the down-time was excessive.
- b. All active redundant FP's and all energized passively redundant FP's will be reverified if necessary to assure that the vehicle is safe to launch (even if reverified previously per item a above). This reverification shall include items identified in the Critical Items List (CIL).
- c. LRU's removed from the vehicle for field maintenance must be reverified prior to reinstallation in the vehicle. Functional verification of the affected paths within the LRU will suffice when the repair involves replacement of shop replaceable units (SRU's) only. Repair involving more than SRU's (i. e. soldering, potting) will necessitate complete acceptance testing of the LRU, including environmental acceptance testing when applicable.

3.4.4 Pre-Flight Phase

3.4.4.1 General. Pre-flight phase activities consist of final manufacturing assembly and checkout, buildup of the booster assemblies, stacking of the booster assemblies on the Mobile Launcher Platform, integrated tests, and launch.

3.4.5 Flight.

3.4.5.1 General. MSFC will be responsible for SRB flight data analysis to insure acceptable performance of the SRB element and to initiate any design changes required to assure SRB performance in accordance with Shuttle System objectives.

3.4.6 Post-Flight.

3.4.6.1 General. Post-flight activities will include retrieval and turnaround of the SRB. MSFC will evaluate retrieval and turnaround activities and equipment operation during the DDT&E phase to assure SRB equipment capability of supporting shuttle system operational flight requirements.

Maintenance techniques and procedures will be verified during this phase.

3.5 RESPONSIBILITIES AND DOCUMENTATION REQUIREMENTS. This section defines the planning and implementation of the SRB verification program and requirements for preparation, review and approval of program documentation. Implementation of the SRB verification program will be initiated by the preparation and release of the first tier documentation prescribed under Volume IV as shown in Exhibit 3.5.2-1.

3.5.1 Responsibilities. Exhibit 3.5.1-1 lists the major responsibilities and associated documentation that govern the SRB subsystem managers in implementing the SRB Verification Program and in formulating the detailed program plans. As indicated by the Exhibit, each SRB subsystem manager will be responsible for implementing and controlling the verification program at the component and subsystem levels, while the SRB project office will be responsible at the element level.

3.5.2 Documentation Requirements. The documentation system established for the SRB program is illustrated in Exhibit 3.5.2-1. The contents of each document are summarized in Exhibit 3.5.2-2. The total verification requirements are expanded and grouped into individual requirements according to the phases of the SRB subsystem verification program. These requirements documents form the basis and justification for the component, subsystem, and element test programs. Implementation is carried out through lower-level detailed plans and procedures. Data from these programs will be used to certify the SRB as flightworthy and ready for operational status.

3.5.3 Verification Status. The SRB Project Office will maintain an overall status of all verification documentation and verification activities based upon inputs furnished by the SRB subsystem managers. Status information will include documentation requirements, responsibilities and schedules for the preparation of all verification documentation, and responsibilities and schedules for the implementation of all verification activities prescribed in the prepared documents. Status information in turn will be provided to JSC as required to furnish overall visibility of the SRB verification program.

3.5.4 SRB Project Office Recording, Reporting, and Record-keeping Responsibilities. SRB Project Office shall keep complete records, on a test or analysis basis, of the configuration of hardware, software and documentation used to conduct the test or analysis.

TEST PROGRAM	ACTIVITY	TESTING ORGANIZATION	SRB PROJECT OFFICE (Subsys Mgrs)	DEVELOPMENT ORGANIZATION	MSFC R&QA OFFICE	SHUTTLE PROJECT OFFICE	SHUTTLE PROGRAM OFFICE	SHUTTLE SYSTEMS CONTRACTOR	DOCUMENT TITLE
Subsystem Development	Subsystem Development Plan		Generate Plan	Support	Selected Review				Subsystem Development Plan
	Component Development Test Requirements			Generate Test Requirements	Selected Review				Component Development Test Requirements
	Test Procedures	Generate Procedures	Monitor	Review and Approve	Selected Review				Development Test Procedures
	Test/Analysis Reports	Generate Test Reports	Monitor	Review and Analyze Test Reports/Generate Analysis Reports	Selected Review				Development Test/Analysis Reports

SRB VERIFICATION RESPONSIBILITY MATRIX

EXHIBIT 3.5.1-1

TEST PROGRAM	ACTIVITY	TESTING ORGANIZATION	SRB PROJECT OFFICE (Subsys Mgrs)	DEVELOPMENT ORGANIZATION	MSFC RSQA OFFICE	SHUTTLE PROJECT OFFICE	SHUTTLE PROGRAM OFFICE	SHUTTLE SYSTEMS CONTRACTOR	DOCUMENT TITLE
Subsystem Certification	Requirements Identification	Review	Generate Requirements	Support	Review	Review	Review	Review	Subsystem & Component Certification Requirements Doc.
	Test/Analysis Plans	Generate Test Plans	Review and Approve	Review Test Plans/Generate Analysis Plans	Review	Review			Certification Test/Analysis Plans
	Test Procedures	Generate Test Procedures	Review and Approve	Review	Review				Certification Test Procedures
	Test/Analysis Reports	Generate Test Reports	Review and Approve	Review & Analyze Test Reports/Generate Analysis Reports	Review	Review			Certification Test/Analysis Reports
	Certificate of Qualification (COQ)		Approve COQ	Generate COQ	Approve and Maintain in COQ Files				Certificate of Qualification
	Certified Hardware List (CHL)		Approve CHL	Review CHL	Generate CHL				Certified Hardware List
	Certification Status Reports	Generate Component & Subsystem Status Information	Review Status Reports	Generate Analysis Status Information	Maintain Status Information, Prepare and Approve Project Level Status Reports	Review Status Reports	Review Status Reports		SRB Certification Status Reports

SRB VERIFICATION RESPONSIBILITY MATRIX (CONTINUED)

EXHIBIT 3.5.1-1

TEST PROGRAM	ACTIVITY	TESTING ORGANIZATION	SRB PROJECT OFFICE (Subsys Mgrs)	DEVELOPMENT ORGANIZATION	MSFC RAQA OFFICE	SHUTTLE PROJECT OFFICE	SHUTTLE PROGRAM OFFICE	SHUTTLE SYSTEMS CONTRACTOR	DOCUMENT TITLE
Subsystem Acceptance	Requirements Identification	Review	Generate Requirements	Support	Review	Review			Subsystem & Component Acceptance Test Req. Documents
	Test Plans	Generate Test Plans	Review and Approve	Review	Review	Review			Acceptance Test & Checkout Plans
	Test Procedures	Generate Test Procedures	Review and Approve	Review	Review				Acceptance Test & Checkout Procedures
	Test Summary Reports	Generate Test Reports	Review and Approve	Review and Analyze	Review	Review			Acceptance Test Summary Reports

SRB VERIFICATION RESPONSIBILITY MATRIX (CONTINUED)

EXHIBIT 3.5.1-1

TEST PROGRAM	ACTIVITY	TESTING ORGANIZATION	SRB PROJECT OFFICE	DEVELOPMENT ORGANIZATION	MSFC RQA OFFICE	SHUTTLE PROJECT OFFICE	SHUTTLE PROGRAM OFFICE	SHUTTLE SYSTEMS CONTRACTOR	DOCUMENT TITLE
Element ACQ & Pre-flight Check-out	Requirements Identification	Review	Define SRB Requirements	EL-53 Generate; Others Support	Review	Review	Review	Review	Operation and Maintenance Requirements and Specifications Doc.
Element Flight Tests	Requirements Identification	Review	Define SRB Requirements	EL-42 Generate; Others Support	Review	Review	Review	Review	VFT Test Requirements Doc.

SRB VERIFICATION RESPONSIBILITY MATRIX (CONTINUED)

EXHIBIT 3.5.1-1

EXHIBIT 3.5.2-2: SRB VERIFICATION PROGRAM DOCUMENTATION

Shuttle System Flight and Ground System Specification, JSC 07700 Vol. X

Provides requirements definition for shuttle system performance, design and verification.

Shuttle Master Verification Plan Vol. I, General Approach and Guidelines

Provides guidelines for development of individual and combined element master verification plans.

Shuttle Master Verification Plan Vol. II, Combined Element Verification Plan

Provides requirements definition for shuttle system combined element Major Ground Tests

Contract End Item Specification, Part I, Solid Rocket Booster (SRB) CP013M00000A

Provides requirements definition for SRB performance, design and verification. Interface requirements included by reference to the appropriate ICD's.

Shuttle Master Verification Plan Vol. IV, Solid Rocket Booster Verification Plan

Defines verification program applicable to Solid Rocket Booster. Contains SRB level requirements and planning information. Generated and maintained by the MSFC Systems Integration Branch, SA&I Laboratory.

Subsystem Development Plan

Define subsystem components, schedules for testing, and responsible test organization. Component engineers interface directly with test laboratories with test requirements. Generated by subsystem managers; supported by development organization. Selected review by MSFC R&QA Office.

Component Development Test Requirements

Identify tests to be performed, requirements, criteria, constraints, test sequence and number of test specimens. Define hardware orientation for test and identify configuration. Generated by development organization; selected review by MSFC R&QA Office.

EXHIBIT 3.5.2-2 (CONTINUED)

Development Test Procedures

Define (1) requirements to be satisfied, (2) test sequence, (3) required test equipment, (4) pass fail criteria, (5) test configuration (6) data sheets, (7) reference documentation.

Generated by testing organization; review and approval by development organization. Monitored by subsystem manager, selected review by MSFC R&QA Office.

Development Test/Analysis Reports

Include brief discussion of (1) test/analysis results and failures, (2) references and requirements, (3) test/analysis methods (4) test equipment list, (5) data requirements, (6) failure criteria, (7) test results (8) functional data sheets (9) environmental data (10) vibration PSD plots, (11) shock plots, (12) temperature log sheet (13) photographs.

Test reports generated by testing organizations. Review and analysis by development organizations. Monitored by subsystem managers. Selected review by MSFC R&QA Office.

Analysis reports generated by development organization; monitored by subsystem managers. Selected review by MSFC R&QA Office.

A listing (or reference to a listing) of the configuration of hardware, software and documentation, for both the flight and ground systems utilized during each test or analysis shall be included as an appendix to the test or analysis reports.

Subsystem Certification Requirements Documents

Define subsystem level certification requirements, methods and test location, i. e., EIVT, static firing, etc. Contains as a minimum, subsystem description, test requirements, criteria and constraints, test sequence, degree of configuration control (hardware, documentation, software), major control points, and reporting requirements to be met by testing organization. Also included will be a matrix defining each environmental condition to be evaluated versus all subsystem components showing the method by which each will be certified. All subsystem level requirements to be reflected in the component certification requirements documents will be specified.

Generated by subsystem managers with support from development organizations. Review by MSFC R&QA Office. Submit to Shuttle Program Office and systems contractor.

EXHIBIT 3.5.2-2 (CONTINUED)

Component Certification Requirements Documents

Define component level certification requirements, including method of certifying each. Minimum requirements include component description; test requirements, criteria, and constraints; number of test specimens required; location (i.e., in-house, supplier); configuration control (hardware, documentation, software); schedules; reporting requirements, and certification requirements matrix.

Generated by subsystem manager; supported by development organization. Review by MSFC R&QA Office. Submit to Shuttle Program Office and systems contractor.

Certification Test/Analysis Plans

Contain detail implementation data to satisfy requirements specified in certification requirements documents. Identify how test/analysis will be performed. Defines test equipment and facility requirements. Includes test hardware flow schedules and personnel requirements. Specify documentation required, i.e., schematic diagrams, ICD's, etc. For analysis, define, as a minimum, (1) methods to be used (2) guidelines to be followed (3) requirements to be satisfied (4) data inputs required, i.e., test data, if applicable, (5) results to be achieved.

Test plans generated by testing organization; approved by subsystem managers. Review by development organizations, MSFC R&QA Office and Shuttle Project Office. Analysis plans generated by development organization; approval and review same as test plans.

Certification Test Procedures

Detail test operations including (1) requirements to be satisfied, (2) step-by-step test sequence, (3) required test equipment (4) pass/fail criteria, (5) test configuration, (6) data sheets, (7) reference documentation.

Generated by testing organization; approval by subsystem managers. Review by development organization and MSFC R&QA Office.

Certification Test/Analysis Reports

Include (1) brief discussion of test/analysis results and failures, (2) references and requirements, (3) test/analysis methods (4) test equipment list, (5) data requirements, (6) failure criteria, (7) test results, (8) functional data sheets, (9) environmental data (10) vibration PSD plots, (11) shock plots, (12) temperature log sheet (13) photographs.

EXHIBIT 3.5.2-2 (CONTINUED)

Test reports generated by testing organizations. Review and analysis by development organizations. Approval by subsystem managers. Review by MSFC R&QA Office and Project Office.

Analysis reports generated by development organizations. Approval by subsystem managers. Review by MSFC R&QA Office, Shuttle Project Office.

A listing (or reference to a listing) of the configuration of hardware, software and documentation, for both the flight and ground systems utilized during each test or analysis shall be included as an appendix to the test or analysis reports.

Certification Status Reports

Provide status of component and subsystem certification activities as identified in the subsystem certification plan/requirement documents and include:

- (1) Test/Analysis start and completion dates (Scheduled and actual)
- (2) Test/Analysis organization and location
- (3) Identification of hardware
- (4) Test plans and test procedures preparation start and completion dates (Schedule and actual)
- (5) COQ approval status

Certification status information generated by testing and development organizations. All certification status information to be submitted to MSFC R&QA Office (EG24) monthly. R&QA office responsible for maintaining status information and preparing monthly SRB Certification Status Reports and forwarding to Shuttle Program Office. SRB Project Office review status reports.

EXHIBIT 3.5.2-2 (CONTINUED)

Certificate of Qualification

Formal statement for each item of flight hardware certified and approved for use on Shuttle program.

Prepared for each item requiring certification by development organization, using MSFC Form 511 or equivalent form. Forwarded to MSFC R&QA Office for approval and file maintenance. Approval by subsystem managers.

Certified Hardware List

List of all flight hardware certified and approved for use on shuttle program. Developed as certification is completed. Used at FRR to certify flight readiness. Includes information contained in COQ for each item of hardware.

Generated and maintained by MSFC R&QA Office. Review by development organization. Approved by SRB Project Office.

Certificate of Flight Readiness

Formal declaration by SRB Project Manager of design integrity and readiness for flight. Based upon satisfactory completion of all verification activities.

Major Ground Test Requirements Documents

Define subsystem and element level verification requirements to be satisfied by major ground tests. Test definition includes objectives, responsibilities, and sequence. Test details include load conditions, hardware, fixture and facilities requirements, general requirements, test parameters, instrumentation and data requirements. Identifies development versus certification testing. Separate document for:

- a. EIVT - Generated by EL52
- b. Static Structural tests - Generated by EP41
- c. SRM static firing tests - Generated by EL
- d. MVGVT - Generated by JSC
- e. SAIL - Generated by JSC
- f. Vibroacoustic tests - Generated by TBD
- g. ET/SRB Separation tests - Generated by EL42

All documents reviewed by MSFC R&QA Office and SRB Project Office.

Major Ground Test Plans

Generally contain the same information as defined for certification test plans.

Generated by testing organizations. Review by MSFC R&QA Office and SRB Project Office.

EXHIBIT 3.5.2-2 (CONTINUED)

Major Ground Test Procedures

Generally contain the same information as defined for certification test procedures.

Generated by testing organizations. Review by MSFC R&QA Office and SRB Project Office.

Major Ground Test Reports

Generally contain the same data as defined for certification test reports.

Generated by testing organization; review by development organizations, MSFC R&QA Office and SRB Project Office.

Subsystem/Component Acceptance Test Requirements Documents

Generally contain the same information as defined for certification test requirements documents.

Responsibilities for preparation and review also the same.

Acceptance Test/Checkout Plans

Generally contain the same information as defined for certification test plans.

Responsibilities for preparation and review also the same.

Acceptance Test/Checkout Procedures

Generally contain the same information as defined for certification test procedures.

Responsibilities for preparation and review also the same, except MSFC R&QA Office will review and approve procedures prepared by MSFC; review procedures prepared by MSFC contractors.

Acceptance Test Summary Reports

Generally contain the same data as defined for certification test reports.

Responsibilities for preparation and review also the same, except MSFC R&QA Office will review and approve reports prepared by MSFC; review reports prepared by MSFC contractors.

EXHIBIT 3.5.2-2 (CONTINUED)

Subsystem/Component Assembly and Prelaunch Checkout Requirements Inputs

Define subsystem checkout requirements as derived from the subsystem certification, major ground test, and acceptance test requirements documents. Also, the requirements for checkout of some individual components, via special test connections, shall be specified. Data to be incorporated in the OMRSD.

Generated by Ground Systems Analysis Branch, SA&I Laboratory.

SRM Operation and Maintenance Requirements and Specification Document (OMRSD)

Defines mandatory requirements (including specifications, tolerances and limits, inspection requirements, special precautions and constraints, etc.) to determine that the SRB is ready for: (1) delivery to launch site, and (2) launch. Includes assembly checkout requirements, prelaunch checkout requirements, and launch operations. Enables identification of tests to be conducted at the assembly checkout site prior to delivery versus tests required after delivery to launch site. Incorporates results of post-flight verification assessment as applicable to assure adequate refurbished hardware after refurbishment/turnaround activities.

Generated by MSFC Ground Systems Analysis Branch with support by other development organizations. Review by testing organizations, MSFC R&QA Office, and SRB Project Office. Submit to Shuttle Program Office and systems contractor.

KSC Ground Operations Plan

Implementation plan to satisfy pre-flight and post-flight turnaround test/checkout and ground processing requirements.

Generated by KSC with inputs by MSFC.

Test and Checkout Procedures

Developed by KSC. MSFC inputs furnished by OMRSD.

Test Summary Reports

Prepared by KSC.

Vertical Flight Test Requirements Inputs

Consists of combined SRB component, subsystem and element level requirements to be verified during VFT. Defines type data and general location of data source. Identifies requirements to be verified during launch, ascent, separation and recovery. These requirements will be incorporated into the Orbital Flight Test Requirements Document. Requirements will be compiled by MSFC Systems Requirements and Analysis Branch, SA&I Laboratory.

EXHIBIT 3.5.2-2 (CONTINUED)

Vertical Flight Test Requirements Document

Combined element and element verification requirements to be satisfied in flight during orbital flight test program. Generated by JSC.

Post-Flight Test Analysis Requirements Document

Defines detailed SRB verification requirements for post-flight verification phase. Post-flight test/analysis requirement will determine the effects of space flight operations on returned equipment and the effects of launch on launch-site GSE. Consists of assessment by analysis and demonstration. Results of assessment to be reviewed for potential impact on the OMRSD. Requirements include retrieval and refurbishment/turnaround activities.

SRB Operations and Maintenance Plans

Operations plans will describe SRB ground processing. Include functional flow diagrams, activity descriptions, facility and GSE requirements, requirements effecting facility and GSE related to flight hardware design requirements.

Maintenance Plans will be prepared for each level of maintenance, i. e., organizational, intermediate and depot. The maintenance organization, locations, facilities, support and test equipment will be detailed in the plans. All Maintenance significant items will be identified to a recommended level of maintenance through Source, Maintenance and Recoverability (SMR) coding. Maintenance manager-ment procedures will be delineated and the Modification and Repair system will be described.

Support Equipment Requirements Documents

Establish requirements definitions for the design and development of all support equipment. Provides pictorial concepts, test activity matrices including quantities of hardware required and functional flows; identifies specific end items of equipment, flight element nomenclature, element stations, and top assembly drawing numbers. Support Equipment consist of: Special test equipment (STE) which is hardware and software required to support development, qualification testing and checkout of the SRB, subassemblies and other elements during manufacturing buildup and development; Transportation Support Equipment (TSE) which is hardware and software required to support transportation, handling and maintenance of SRB, its subassemblies and other elements to and from contractors facilities, other government facilities and launch site; and Common Support Equipment (CSE) which is any STE or TSE that can be used at more than one use site.

Support Equipment Specifications

Establishes the requirements for performance, design, and verification of the SRB. It also establishes the interface requirements of the SRB by reference to the appropriate ICD.

Generated by SE subsystem manager; review by development organizations.

EXHIBIT 3.5.2-2 (CONTINUED)

Test Facility Activation Plans

Defines the Management Plan for activation of the Test Facilities. This will include: direction of construction/installation; direction and coordination of modifications for launch systems and ground support equipment installation; direction of integration of existing facilities and GSE with new or modified facilities and GSE; direction of facility verification test plans and the associated facility, system, subsystem and equipment tests required for validating the functional readiness; establish test facility activation schedules for facility/systems and equipment installation and related support activities necessary to meet program/project milestones; establish management information system to identify constraints, potential milestones and cost impacts.

Generated by testing organization; review by SRB Project Office.

SE Test and Checkout Procedures

Details test operations and conditions to verify functional parameters of SE to assure compliance with design specifications. Includes step-by-step sequence of operations and data sheets used to assure verification of all requirements for all items of support equipment and ground checkout software. Indicate configuration of all safety critical SE and ground checkout software certified. Contain all information specified for SRB certification test/analysis procedures as applicable to document all certification and acceptance activities.

Generated by testing organization; approval by SE subsystem manager. Review by development organizations and MSFC R&QA Office.

SE Test Summary Report

Contains summary level information supported by the test facility activation plan, performance management and reporting system for SRB certification test/analysis. These reports provide a common base to be utilized by the test engineering personnel to plan, organize work packages, schedule, commit resources, measure performance, and report status. Assessment will be inclusive of the following:

- a. Objectives
- b. Methods of verification
- c. Facilities (including computer/software)
- d. Test-set-up (if applicable)
- e. Test/analysis data (including performance successes/failure for the items being verified)

Generated by testing organizations; review by development organization, MSFC R&QA Office and Shuttle Project Office. Approval by SE subsystem manager.

EXHIBIT-3.5.2-2 (CONTINUED)

A listing (or reference to a listing) of the configuration of hardware, software and documentation, for both the flight and ground systems utilized during each test or analysis shall be included as an appendix to the test or analysis reports.

Certified SE List

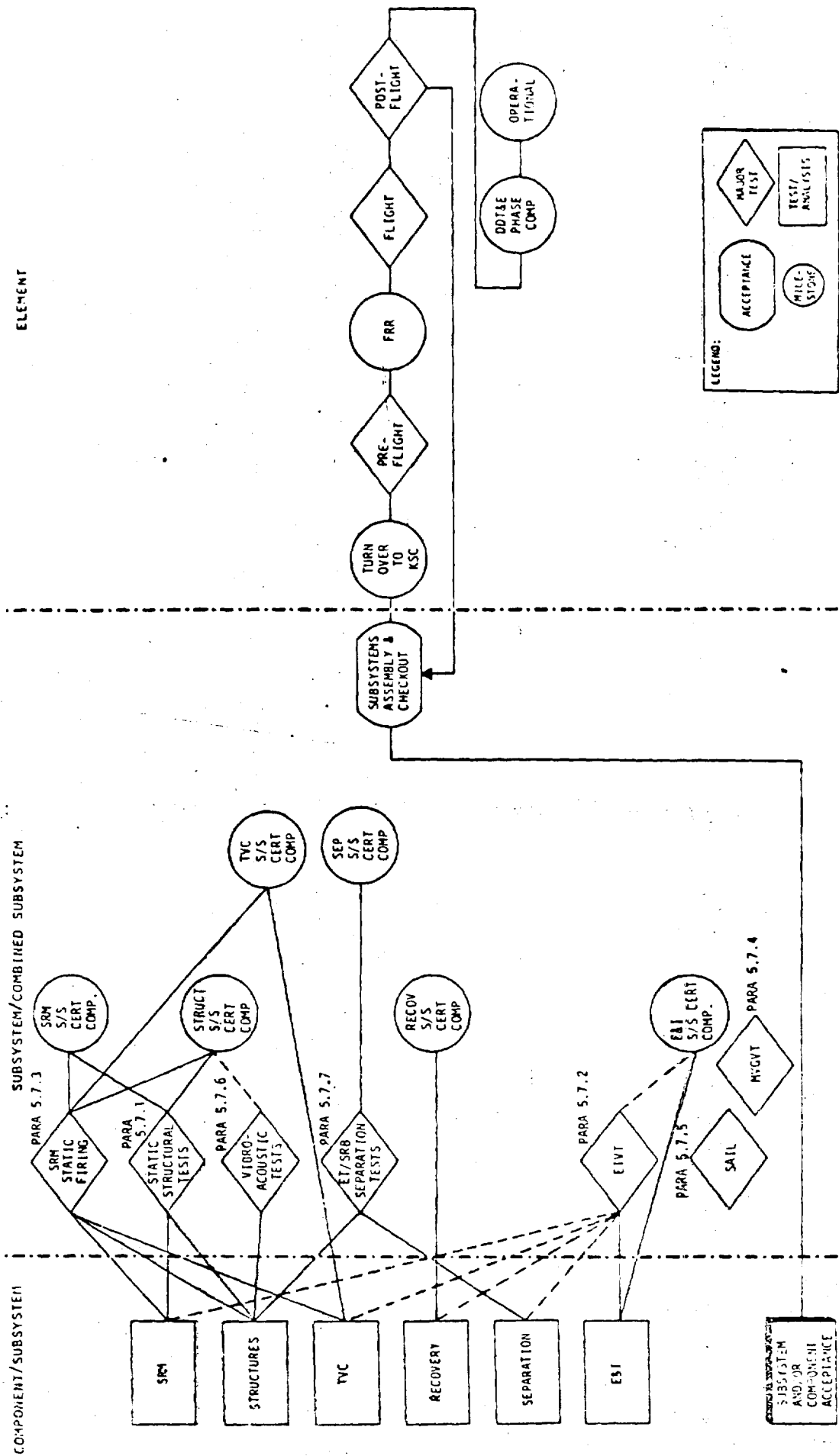
Lists all items of safety critical SE and ground checkout software certified and approved for use on Shuttle program. Developed as certification is completed. Approved for all items which require certification. Contains all information specified above for SRB COQ and CHL.

Generated and maintained by MSFC R&QA Office. Review by development organization. Approved by SRB Project Office.

4.0 SRB VERIFICATION REQUIREMENTS

4.1 SRB VERIFICATION APPROACH. Verification of the SRB will be performed on a building-block basis as shown by the subsystem verifications networks contained in this section and by the element level verification network shown in Figure 4.1-1. As shown by the networks, verification will begin at the component level with development tests and/or analysis to verify the design of the SRB hardware. As the hardware is being developed and qualified, several major ground tests will be conducted by the MSFC laboratories or MSFC contractors to demonstrate that the hardware will meet the design and performance requirements. These tests, descriptions of which appear in paragraph 5.7, have been conceived primarily to verify the SRB hardware at the subsystem level. After completion of the component and subsystem level certification program and following manufacture and acceptance of the hardware, verification activities associated with final manufacturing and assembly will proceed as described in paragraph 5.0.

4.1.1 Verification Matrix. The SRB matrix is contained in the SRB CEI CP013M00000A.



SRB VERIFICATION NETWORK
FIGURE 4.1-1

4.2 ELECTRICAL AND INSTRUMENTATION SUBSYSTEM

4.2.1 Description. The SRB Electrical and Instrumentation Subsystem (E&I) is divided into 5 sub-groups identifiable as to the function performed. They are:

1. Integrated Electronics Assembly (IEA). Communicates with the Orbiter. Routes orbiter commands to perform attitude correction, separation and power distribution. Routes SRB performance data to the Orbiter for use in data evaluation.
2. Development Flight Equipment. Verifies SRB flight performance. Includes tape recording of DFI data during powered flight, during descent, and at impact. Film camera to observe parachute operation. This equipment will be flown only during the DDT&E phase of the Shuttle program.
3. Rate Gyro Assembly. Supplies SRB rate change data to the Orbiter for attitude correction usage.
4. Recovery Aids. RF Beacons and flashing light assemblies are used to locate SRBs and frustums.
5. Range Safety System. Provides capability to safely destruct the two SRB's and the ET if required. All hardware is mounted on the SRB's only.

The breakdown of the E&I subsystem and associated components follows:

Operational Flight Equipment

- Integrated Electronic Assembly (IEA)
 - Distributor
 - Multiplexer Demultiplexer (MDM)
 - Signal Conditioner
- Recovery Aids
 - RF Beacon
 - RF Beacon Antenna
 - Flashing Light
 - Altitude Switch
 - Recovery Battery
 - Transmitter
- Instrumentation Transducers and Sensors
- Cable Assemblies
- Rate Gyro Assembly (Actual flight status not determined)

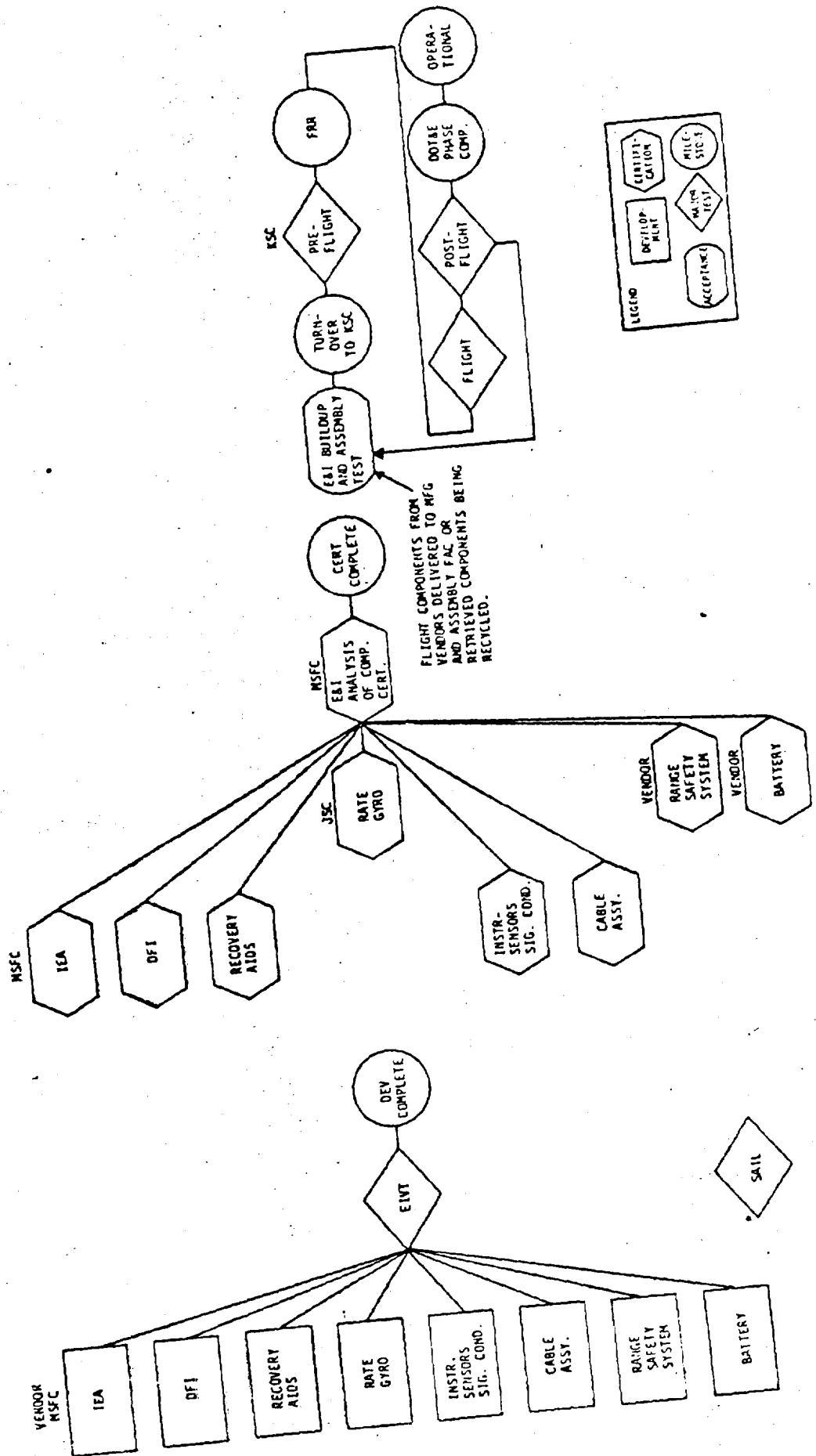
Development Flight Equipment

- Distributor
- Signal Conditioner
- PCM Multiplexer
- FM Multiplexer
- Flight Tape Recorder
- Impact Tape Recorder
- Recorder Amplifier Assembly
- Film Camera Capsule/Timer
- Cable Assemblies
- Battery
- Transducers and Sensors
- IRIG-B Time Code Generator

Range Safety System

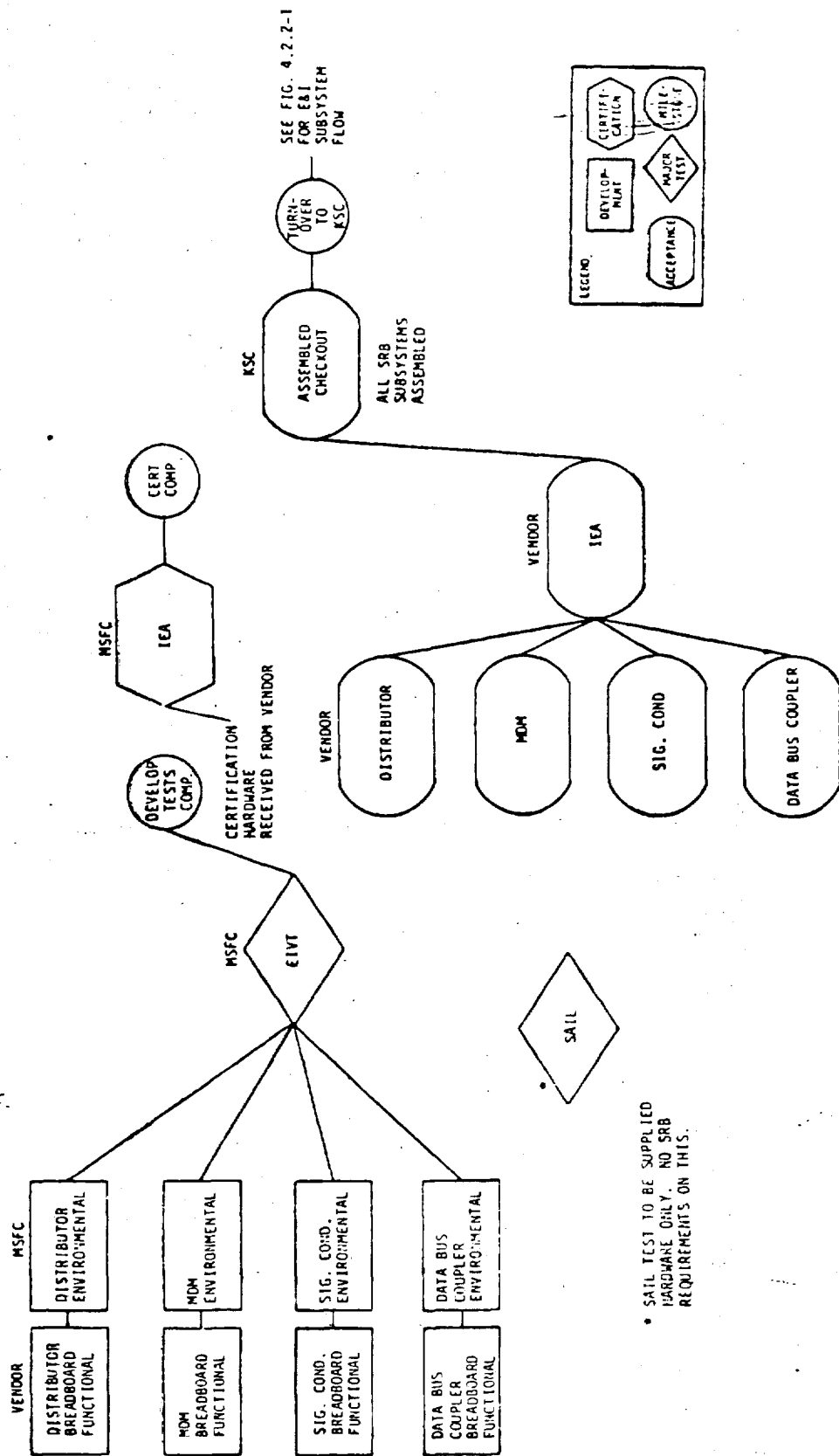
- Receiver
- Decoder
- Antenna
- Hybrid Coupler
- Directional Coupler
- Range Safety Distributor
- Pyrotechnics
- S&A Device

4.2.2 Network - The E&I subsystem verification networks are shown in Figures 4.2.2-1 through 4.2.2-5.

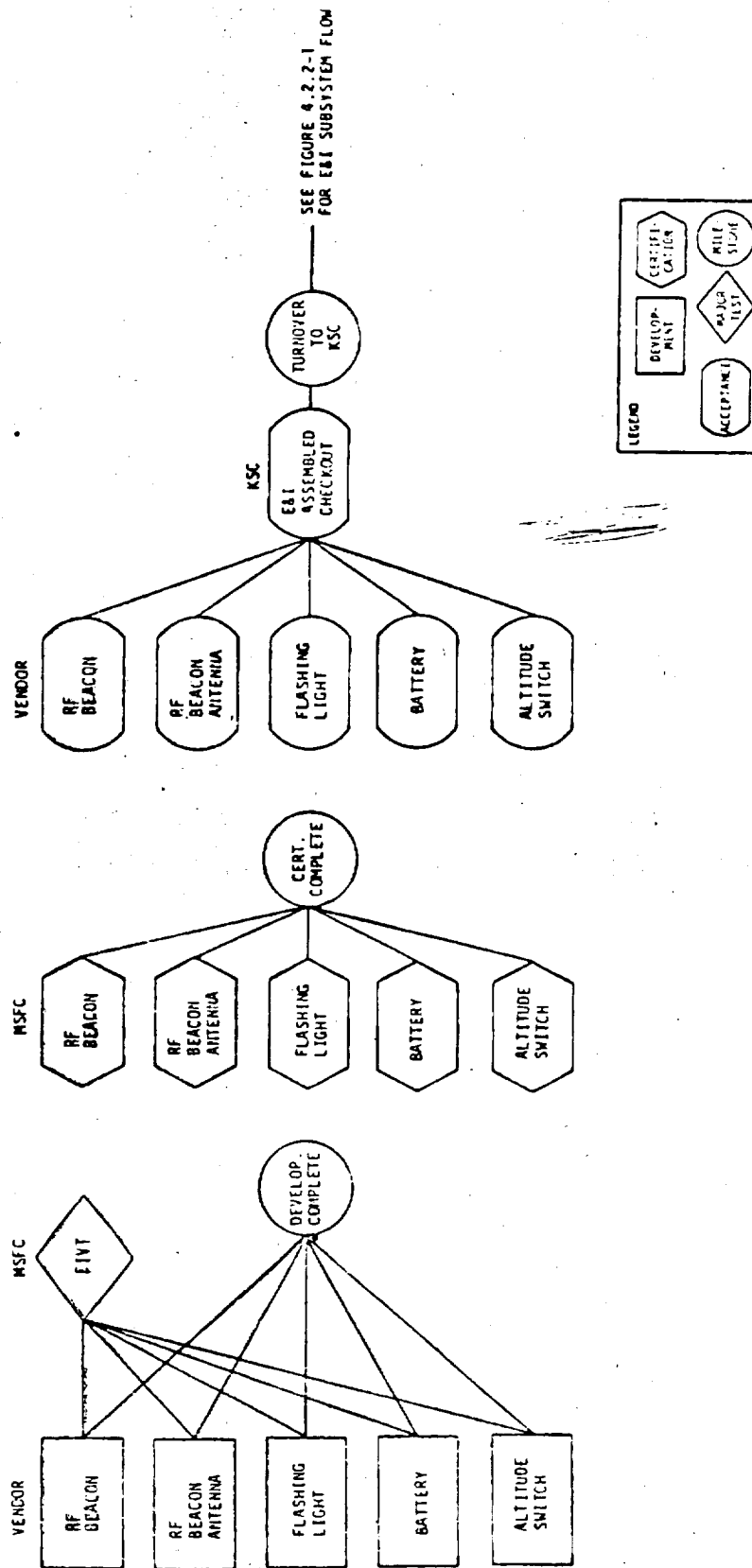


E&I SUBSYSTEM VERIFICATION NETWORK
FIGURE 4.2.2-1

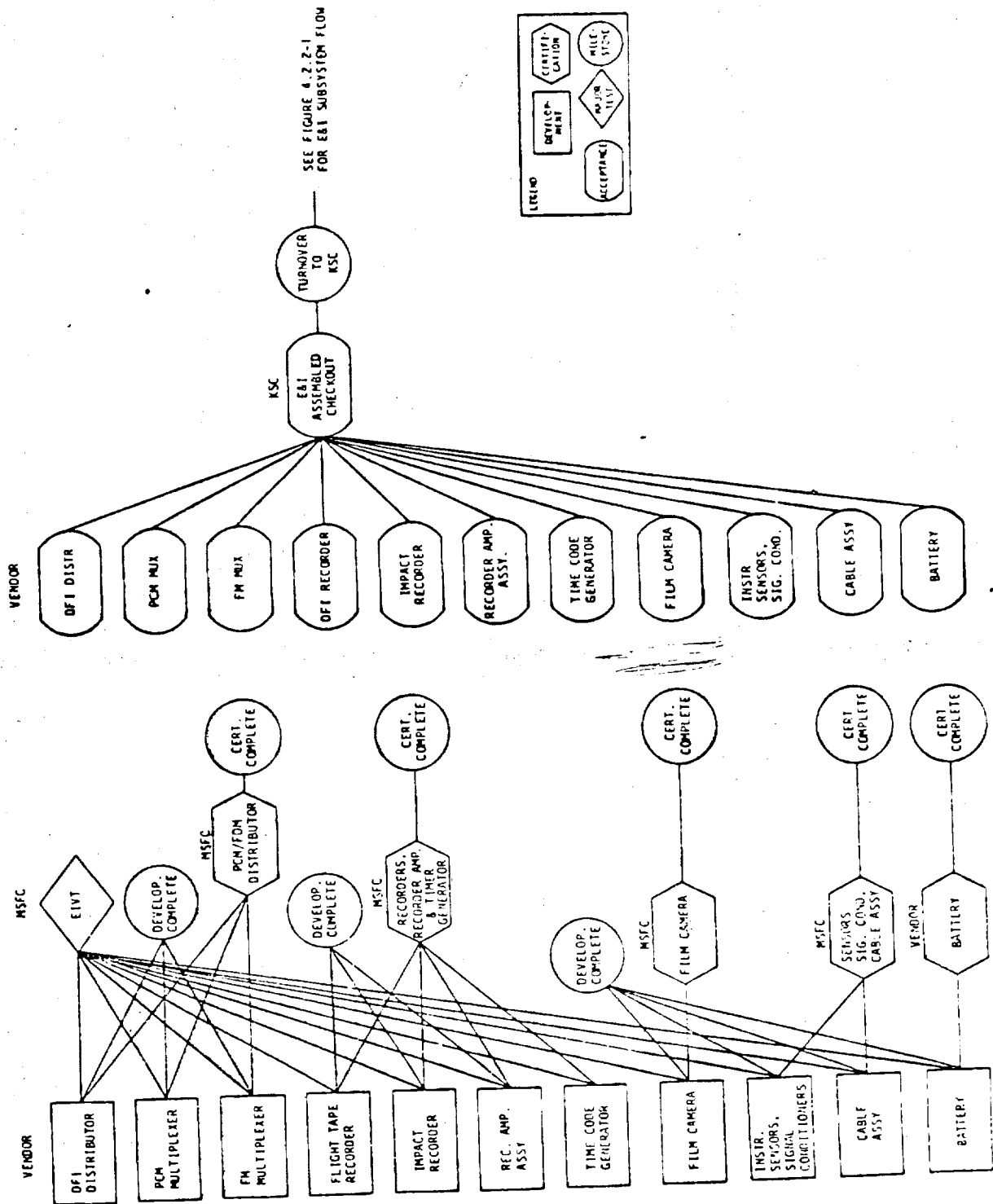
*SAIL TEST TO BE SUPPLIED HARDWARE ONLY.
NO SP5 REQUIREMENTS ON THIS



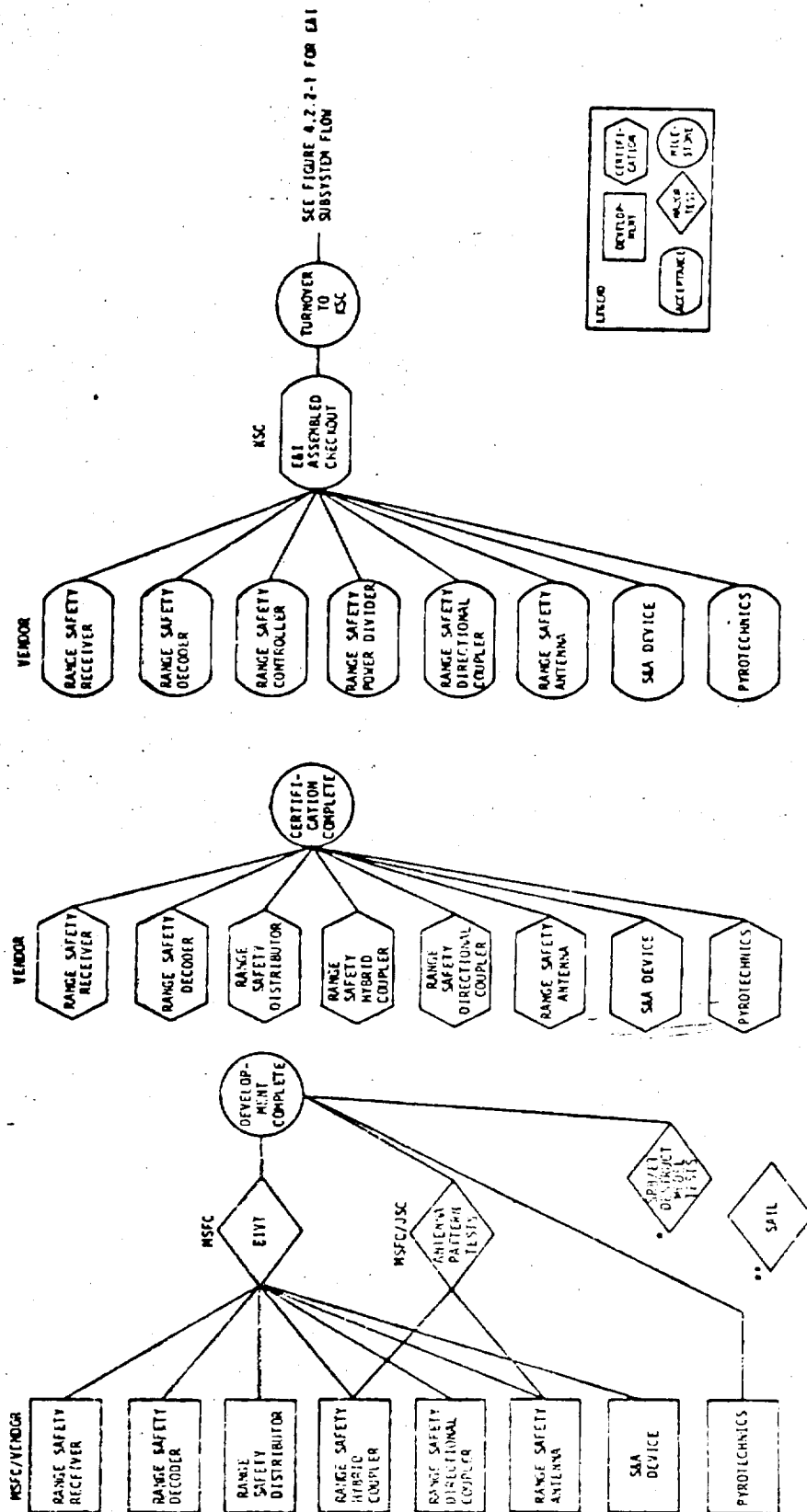
INTEGRATED ELECTRONICS ASSEMBLY VERIFICATION NETWORK
FIGURE 4.2.2-2



RECOVERY AIDS VERIFICATION NETWORK
FIGURE 4.2.2-3



DEVELOPMENT FLIGHT EQUIPMENT VERIFICATION NETWORK
FIGURE 4.2.2-4



*THESE MODEL TESTS WILL BE PERFORMED IF THE RESULTS OF COMPREHENSIVE ANALYSIS BY NAVAL SURFACE WEAPONS CENTER DETERMINE THAT THE SRB ONLY DESTROY SYSTEM WILL DESTROY BOTH THE SRB AND THE ET.

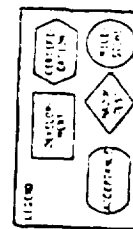
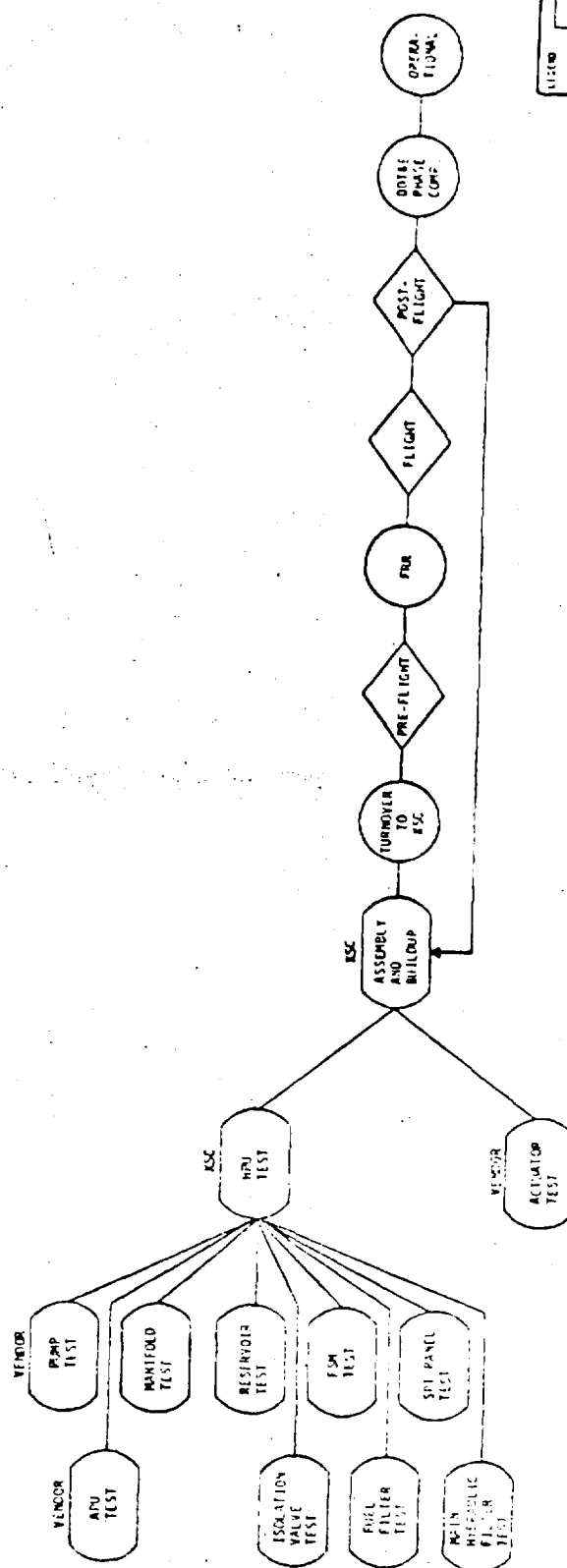
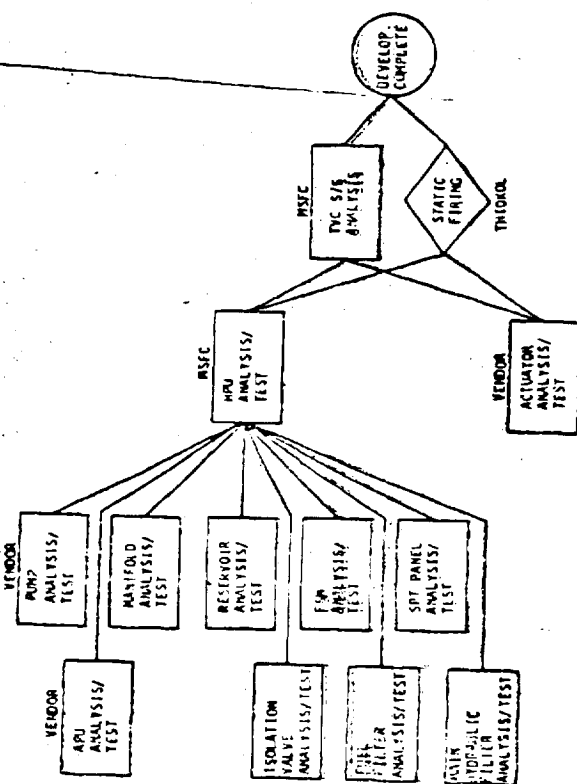
**SAIL TEST TO BE SUPPLIED HARDWARE ONLY. NO SRB REQUIREMENTS ON THIS.

RANGE SAFETY SYSTEM VERIFICATION NETWORK
FIGURE 4.2.2-5

4.3 THRUST VECTOR CONTROL SUBSYSTEM.

4.3.1 Description. The main components of the Thrust Vector Control Subsystem (TVC) are the servoactuators (2) and a redundant hydraulic power unit (HPU). Each HPU consists of an auxiliary power unit, fuel supply module, hydraulic reservoir, manifold, valves, filters and interconnecting plumbing, and a support panel which houses all of the other components. The TVC subsystem is mounted on one half of the aft skirt. One end of the servoactuators is connected to the skirt while the other end is attached to the SRM nozzle extension. Receiving command signals from the Orbiter through the SRB E&I subsystem, the TVC subsystem provides thrust vector control of the SRB and provides to the Orbiter the TVC system status.

4.3.2 Network - The TVC subsystem verification network is shown in Figure 4.3.2-1.

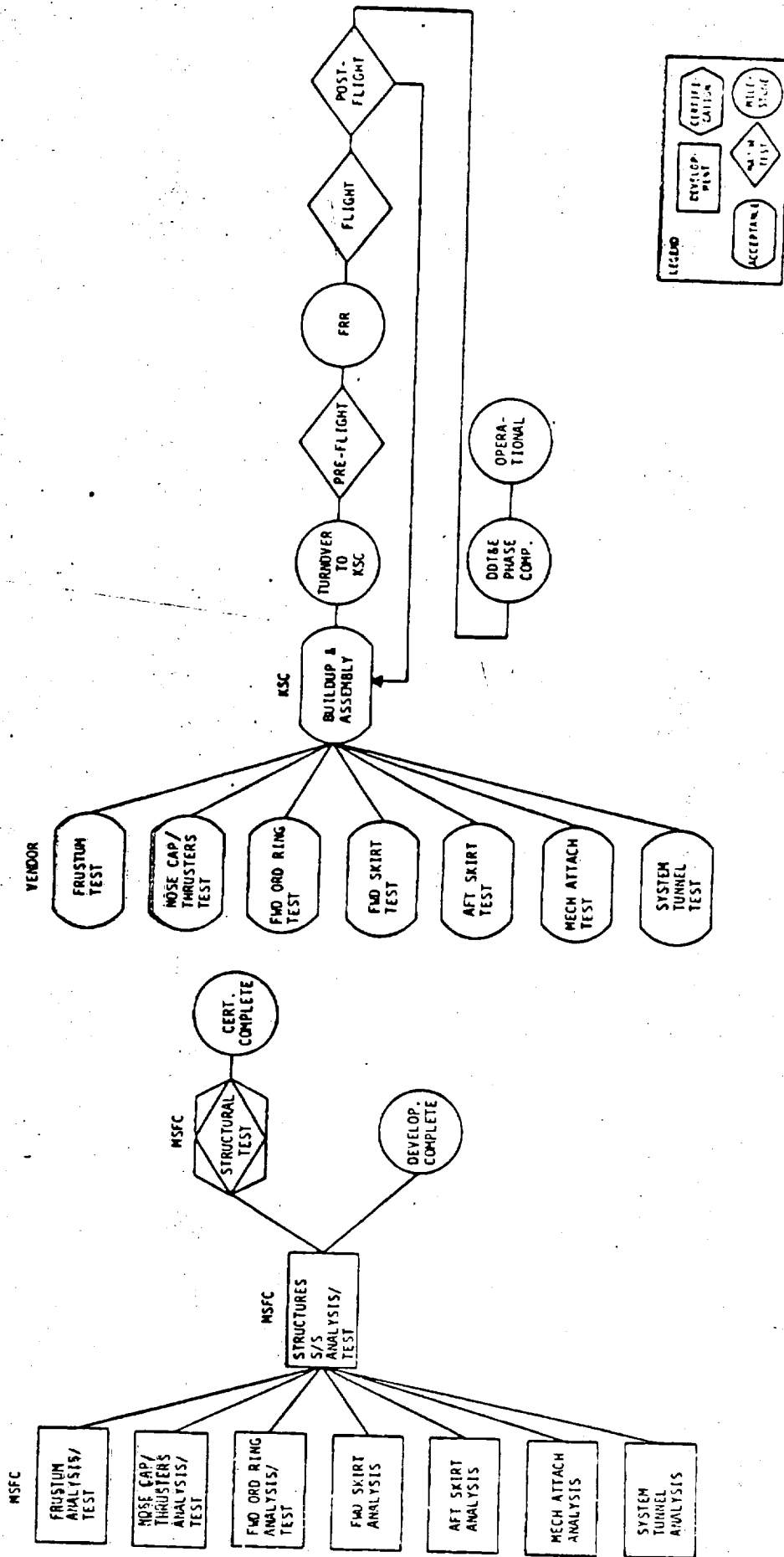


TVC SUBSYSTEM VERIFICATION NETWORK
FIGURE 4.3.2-1

4.4 STRUCTURAL SUBSYSTEM

4.4.1 Description. The Structural Subsystem includes the nose assembly (frustum, nose cap and thrusters), forward ordnance ring, forward skirt including the forward ET/SRB attach fitting, ET attach ring and aft attach struts, aft skirt, external system tunnel, and structure for mounting other SRB subsystem components. The nose assembly houses, as well as protects, the recovery system from aerodynamic heating. A separation motor module is located in the frustum. The ordnance ring, located between the forward skirt and the frustum, and containing a mild detonating fuse, provides a means to separate the frustum from the SRB following SRB separation from the ET. The forward skirt, located between the forward rocket motor segment and ordnance ring, houses the E&I subsystem and includes attach hardware for the recovery subsystem and the ET. The ET attach ring encircles the aft rocket motor segment and the three ET attach struts are secured to this ring. The aft skirt and associated launch support structure provide thermal and aerodynamic protection for the SRM nozzle, the TVC and E&I subsystems, and the aft separation motors. In launch configuration (2 SRB's), this structure supports the Space Shuttle Vehicle on the MLP. The system tunnel provides lightning protection, thermal/aerodynamic protection, and housing for the range safety system linear shaped charge and for the OFI and DFI electrical cabling, which extends between the forward skirt connector and the aft skirt cable feed-through, with additional routing along the ET attach ring and the attach struts.

4.4.2 Network. The Structural subsystem verification network is shown in Figure 4.4.2-i.



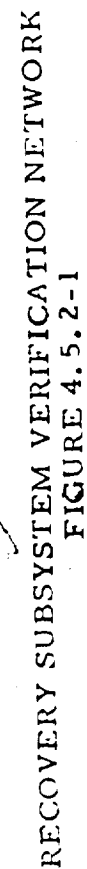
STRUCTURAL SUBSYSTEM VERIFICATION NETWORK
FIGURE 4.4.2-1

4.5 RECOVERY SUBSYSTEM

4.5.1 Description. The SRB Recovery Subsystem includes a pilot parachute, a drogue parachute and a main parachute assembly with explosive ordnance deployment devices, electronic and visual location aids, and flotation equipment. Following separation of the SRB from the ET, the recovery sequence is initiated by the separation of the nose cap from the frustum at approximately 19,000 feet by an altitude switch. This same switch also turns on the location aids (flashing lights and RF Beacon) located on the forward skirt. An altitude switch in the frustum initiates the firing of three thrusters in the frustum which blow the nose cap from the frustum deploying the pilot parachute which in turn deploys the drogue parachute. After opening, the drogue parachute stabilizes and decelerates the SRB until an altitude switch initiates separation of the frustum from the SRB forward skirt at an altitude of approximately 9,000 feet. The drogue parachute continues to support the frustum until water impact at which time a salt water activated switch turns on the frustum location aids (flashing lights and beacon). After opening through two reefing stages, the three parachutes in the main parachute assembly decelerate the SRB to a nominal water impact and are released from the SRB by a water impact switch initiated signal. A salt water activated switch turns on the main parachute location aids (flashing lights and beacon).

The location aids on the frustum, the main parachutes and the SRB will operate continuously for 72 hours to facilitate location by the ocean retrieval team. The frustum and main parachutes contain flotation material to prevent them from sinking. The SRB is maintained in a vertical position in the water by air in the sealed forward skirt compartment and air captured in the spent SRM casings.

4.5.2 Network. The recovery subsystem verification network is shown in Figure 4.5.2-1.



4.6 SEPARATION SUBSYSTEM

4.6.1 Description. The Separation Subsystem includes four ordnance-actuated separation bolts that allow SRB separation from the ET and eight solid Booster Separation Motors (BSM) that provide the separation forces to translate the SRB away from the ET/Orbiter. The four separation bolts are located, one in the forward attach point and three in the aft attach struts, between the SRB and ET. The eight BSM's are mounted four on the frustum and four on the aft skirt.

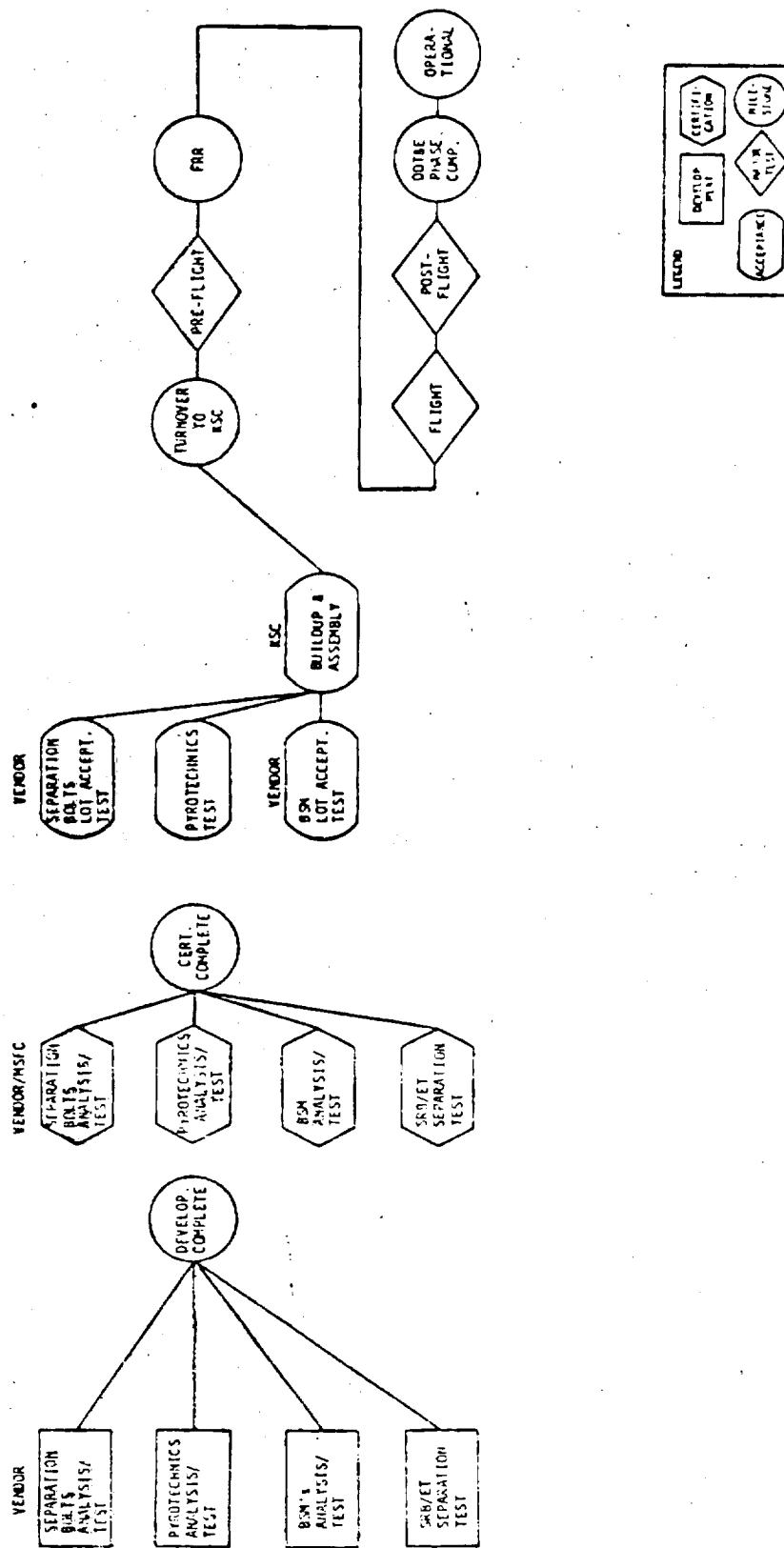
Separation of the SRB from the Orbiter/ET is initiated by hardwire command from the Orbiter to the SRB Integrated Electronic Assembly after SRB burnout. Activation of the four separation bolts and the eight separation motors for each SRB is initiated simultaneously by redundant separation signals from the SRB IEA's, which will be sent to each of the SRB/ET attach points and to each of the SRB frustum and aft skirt BSM's.

The separation signals from the SRB IEA's to the SRB/ET attach points initiate two redundant Standard Manned Spaceflight Initiator (SMSI) pressure cartridges at each attach point.

The separation signals to the Booster Separation Motors (BSM) located in the frustum initiate redundant SMSI detonators which are mounted on separate CDF manifolds. The CDF manifolds are linked to the BSM by means of the CDF assemblies and initiators. An identical ordnance chain is provided for the BSM's located on the aft skirt.

Electrical disconnect between the SRB and the ET is accomplished by pull-away connectors located on the SRB aft struts.

4.6.2 Network - The Separation subsystem verification network is shown in Figure 4.6.2-1.

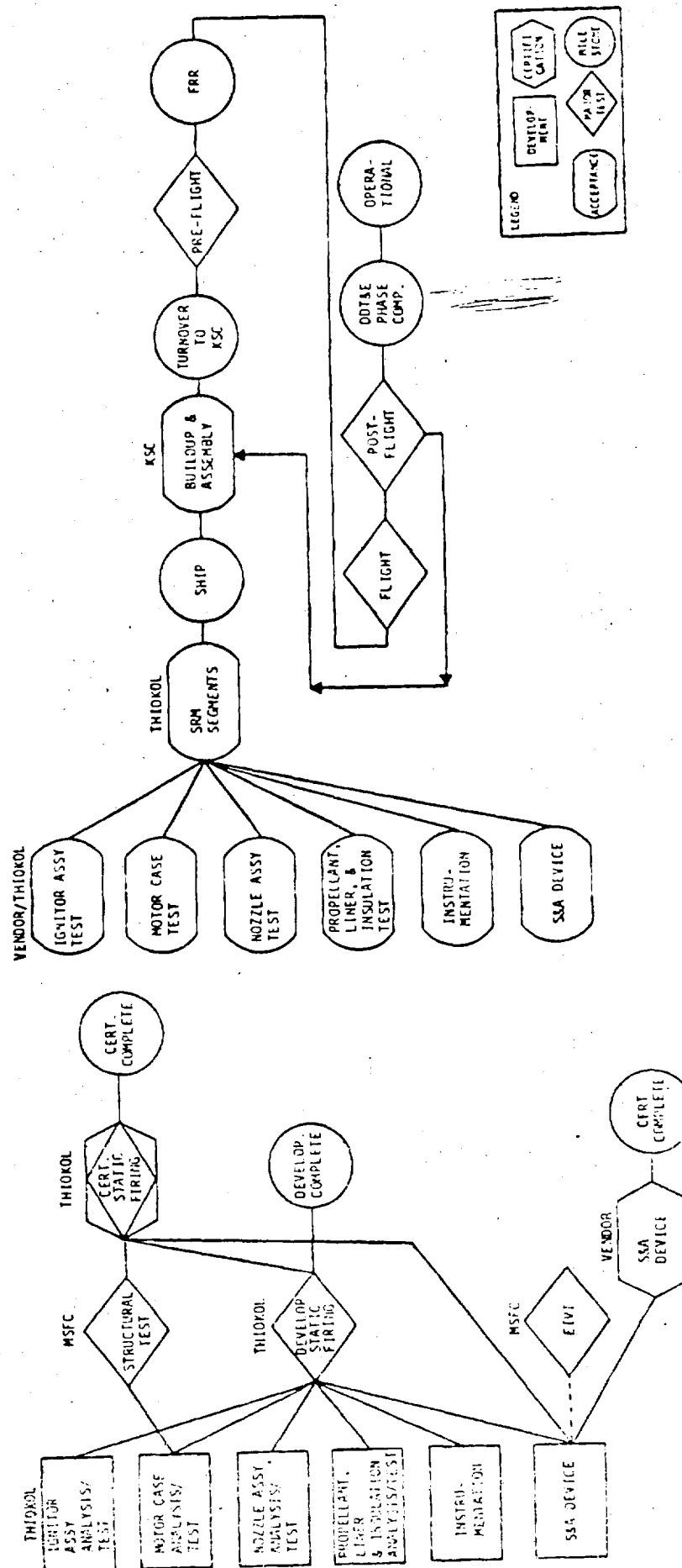


SEPARATION SUBSYSTEM VERIFICATION
NETWORK
FIGURE 4.6.2-1

4.7 SOLID ROCKET MOTOR SUBSYSTEM

4.7.1 Description. The Solid Rocket Motor (SRM) subsystem for each SRB is made up of a forward motor segment, two center motor segments, and an aft motor segment. Each motor segment consists of a cylindrical, weld-free case with clevis-type mechanical joints, liners, insulation, and propellant. The forward motor segment interfaces with the SRB forward skirt and includes the ignitor, initiators and a safe and arm device. The aft motor segment, which mates to the SRB aft skirt, provides for mounting of the movable nozzle to which the TVC actuators are attached. The aft motor segment has provisions for installing the ET attach ring and the four cavity collapse rings. In the stacked configuration, the SRB external cables and system tunnel are attached to and routed along the outside of the SRM segments. Mounting of various operational and development instrumentation transducers is provided at strategic locations on the SRM.

4.7.2 Network - The SRM subsystem verification network is shown in Figure 4.7.2-1.



SRM SUBSYSTEM VERIFICATION NETWORK
FIGURE 4.7.2-1

TVC SUBSYSTEM		SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.2.1.1.1	Ascent Control	M30, 37; T45	T45		K41
3.2.1.1.3.4	SRB Safing	M30, 37			K42
3.2.1.1.4.2	Launch	M30, 37; T45	T45		K41, 42
3.2.1.1.4.3	Ascent	M30, 37; T45	T45		K41, 42
3.2.1.1.4.5.	SRB Recovery Loads	M30, 38	M38		K41, 42
3.2.1.1.5	Shuttle Flight Vehicle Checkout	M30, 38	M37, 38	K40	
3.2.1.7.1	Configuration	M30, 37, 38	M37, 38	K40	K41, 42
3.2.1.7.1.1	General Requirements	M30, 37, 38; T45	M37, 38	K40	K41, 42
3.2.1.7.1.2	Servoactuators	V1, 3, 5, 6, 9; M30, 37, 38; T45	V1, 3, 5, 9; M30, 32, 38	V1	K40, 41
3.2.1.7.1.3	Hydraulic Power Supplies	M1, 30, 37, 38; T45	M37, 38	K40	K41
3.2.3.1	Flight Vehicle Sub-system Functional Reliability	M33, 37	M37, 38	K40	K41, 42
3.2.3.2	Primary Structure Thermal Protection, Pressure Vessels	M33, 37	M37, 38	K40	K41, 42
3.2.3.3	Redundancy Verification	M33, 37; T45	T45	K40	K41, 42
3.2.4	Maintainability	M30, 37, 38; T45	M37, 38; T45	K40	K42

TVC SUBSYSTEM		SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.2.5.1	Useful Life	M37, 38, 32	M37, 38		K41, 42
3.2.5.2	24 Hour Notification for Launch	M38	M38		K40
3.2.5.3	Launch from Standby	M38	M38		K40
3.2.5.4	Launch Recycle	M38	M38		K40
3.2.5.5	On Pad Stay Time	M38	M38		K40
3.2.6	Safety	M37			
3.2.6.1	Safety Design Preferences	M30, 34, 37	M37, 38	K40	K41, 42
3.2.6.3	Materials	M34	M37, 38	M38	K42
3.2.6.3.1	Hazardous Materials	M36, 38	M37, 38	K40	K42
3.2.6.4	Isolation of Hazardous Conditions	M37	M37, 38	K40	K42
3.2.6.5	Protection of Critical Functions	M30, 37	T45	K40	K41, 42
3.2.6.8	Static Electric Protection	V30, 32, 34	M37, 38		K41, 42
3.2.6.11	Contamination	M36, 37, 38	M37, 38	K40, 14	K42
3.2.6.12	Cross Contamination	M30, 37, 38; T45	T45; M37, 38	M38	K41, 42
3.2.6.15	Separation of Critical Functions	M30, 34, 37, T45	M37, 38		

TABLE 4.3.3-1

TVC SUBSYSTEM		SRB VERIFICATION MATRIX				
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD				
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR	TEST
3.2.6.16	Protection of Redundant Components	M30, 34, 37; T45	M37, 38			
3.2.6.17	Isolation of Subsystem Anomalies	M30, 37; T45	M37, 38			
3.2.6.19	Drain, Vent and Exhaust Port Design	M30, 37; T45	T45	K40	K41, 42	
3.2.6.20	Pressure Vessel Protection	M30, 37; T45	T45	K40	K41, 42	
3.2.7.1	Natural Environments	M34	M37, 38		K41, 42	
3.2.7.2	General	M34	M37, 38		K41, 42	
3.2.7.3	Induced Environments	M34	M37, 38		K41, 42	
3.2.8	Transportability/Transportation	V30, 32, 34, 37, 38	M37, 38		K41, 42	
3.2.8.1	Tie Down Capability	V30, 32, 34, 37, 38	M37, 38			
3.2.8.2	Integral Protection Capability	V30, 32, 34, 37, 38	M37, 38			
3.2.9.1	SRB Storage Life	M34, 38	M38			
3.3.1	Selection of Specifications and Standards	M34	M38			
3.3.2.1.1	Materials and Processes	M34, 36	M38			
3.3.2.1.2	Welding	M14				

TABLE 4.3.3-1

TVC SUBSYSTEM		SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.3.2.2.1	Hardware Selection	M37, 38	M38		
3.3.2.2.2	Electrical/Electronic & Electromechanical (EEE)	V34, 36	M38		
3.3.2.2.2.1	Switching Devices	V34, 36	M38		
3.3.2.2.3	Mechanical Parts Selection	V34, 36	M38		
3.3.5.1	Electromagnetic Compatibility and Lightning Protection	M30, 37, 38	M37, 38	K40	K40
3.3.5.3	Electrical Bonding	M34	M38		
3.3.5.4	Soldering	V14	V14	V14	
3.3.5.5	Grounding and Isolation	M10, 30, 37	M37, 38	K40	
3.3.5.7	Redundant Electrical Circuits	M30, 37	M37, 38		
3.3.5.8	Isolation of Test/Monitor Points	M30, 37	T45; M37, 38	K40	
3.3.5.9	Electrical Circuit Routing	M30, 37	M37, 38	K40	
3.3.5.11	Inadvertent Electrical Shorting Due to Debris	V30, 32, 34	M37, 38	K40	K41, 42

TABLE 4.3.3-1

TVCS SUBSYSTEM		SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.3.5.12	Protection of Electrical and Electronic Devices	M30, 34, 37; T45	M37, 38	K40	
3.3.5.13	Avoidance of Matched Pairs	M37	M37		
3.3.5.15	Improper and/or Cross Connection Prevention	M30, 37	M37, 38	K40	
3.3.5.16	Wire and Cable Installations	M30, 37, 38	M37, 38	K40	
3.3.6.1	Design Safety Factors	M30, 37	M37, 38		
3.3.6.2	Ultimate Combined Load	M30, 37, 38; T45	M46; T45		K41
3.3.6.3	Allowable Mechanical Properties	M37, 38	M37, 38		
3.3.6.4	Fracture Control	M30, 37, 38; T45	M46; T45	M38	K41, 42
3.3.6.6	Creep				K41, 42
3.3.6.7	Temperature	M37, 38	T45		
3.3.6.8	Load Conditions	M30, 37, 38	M37, 38		
3.3.6.9	Acroelasticity	M30, 37	M46; T45, M38		K41, 42
3.3.6.10	Stress Concentration	M38	M46; T45, M38	M38	
3.3.6.11	Misalignment & Tolerances	M37, 38	M37, 38		

TABLE 4.3.3-1

TVC SUBSYSTEM		SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CEL NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.3.6.12	Design Thickness	M37, 38	M37		
3.3.6.13	Strength & Stiffness	M30, 37, 38	M46; T45; M38	M38	K41, 42
3.3.6.14	Pressurization	M30, 37, 38	M37, 38		K41, 42
3.3.6.15	Venting	M30, 37, 38; T45	T45	K40	
3.3.6.17	Purging & Flushing	M30, 37	T45		K42
3.3.6.17.1	Hazardous Gases	M30, 37	T45	K40	K42
3.3.6.18	Fasteners	M36	M37		
3.3.6.18.1	Accessibility of Fasteners	M36	M37		
3.3.6.18.2	Screw Threads	M30, 37	M37	K40	
3.3.6.18.3	Captive Fasteners	M30, 37	M37		
3.3.6.20	Leak Protection - External Ports	M30, 37; T45	T45	K40	
3.3.6.21	Hydraulic Systems	M30, 37, 38	M37		
3.3.8.2	Fungus Resistance	M36, 37	M37, 38		K42
3.3.9.1	Stress Corrosion	M30, 36, 37, 38	M38	V14; K40	K42
3.3.9.2	Corrosion Protection	M30, 36, 37, 38	M38	K40; V14	K42
3.3.10	Contamination Control	M30, 36, 37, 38	M38, 14	K40, 14	K42

TABLE 4.3.3-1

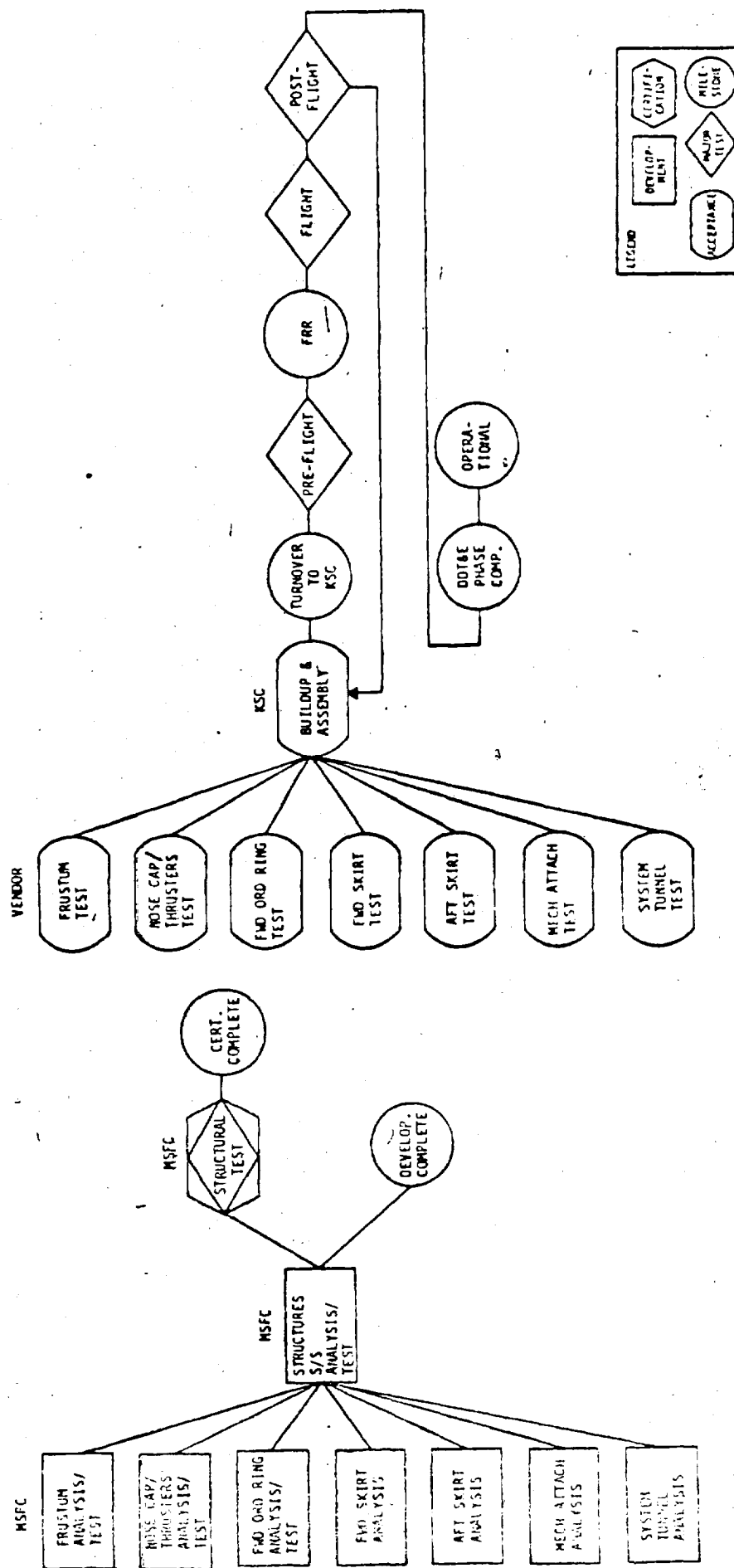
TVC SUBSYSTEM		SRB VERIFICATION MATRIX				
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD				
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST	
3.3.12	Interchangeability & Replaceability	M30, 37	M37, 38	V37, 38		
3.3.13	Identification & Marking	M37	M37	K14, 40		
3.3.13.1	Color Coding & Identification of Safety-Critical Items	M37	M37, 14	K14, 40		
3.3.13.2	Interface Identification	M37	M37, 14	K14, 40		
3.3.13.3	Element Cosmetic Coating & Necessary Markings	M37	M37, 14	K14, 40		
3.3.13.4	Temporarily Installed Hardware Identification	M37, 14	M37, 14	K14, 40		
3.3.14	Workmanship	M36, 37, 38, 14	M37, 14	K14, 40		
3.3.15	Human Performance/ Human Engineering	M30, 37, 38	M37, 38			
3.4	Logistics	M37	M37			
3.5	Personnel and Training	M30, 38	M38	K40	K42	
3.6	Interface Requirements	M37	M37	K40		

4.4 STRUCTURAL SUBSYSTEM

4.4.1 Description. The Structural Subsystem includes the nose assembly (frustum, nose cap and thrusters), forward ordnance ring, forward skirt including the forward ET/SRB attach fitting, ET attach ring and aft attach struts, aft skirt, external system tunnel, and structure for mounting other SRB subsystem components. The nose assembly houses, as well as protects, the recovery system from aerodynamic heating. A separation motor module is located in the frustum. The ordnance ring, located between the forward skirt and the frustum, and containing a mild detonating fuse, provides a means to separate the frustum from the SRB following SRB separation from the ET. The forward skirt, located between the forward rocket motor segment and ordnance ring, houses the E&I subsystem and includes attach hardware for the recovery subsystem and the ET. The ET attach ring encircles the aft rocket motor segment and the three ET attach struts are secured to this ring. The aft skirt and associated launch support structure provide thermal and aerodynamic protection for the SRM nozzle, the TVC and E&I subsystems, and the aft separation motors. In launch configuration (2 SRB's), this structure supports the Space Shuttle Vehicle on the MLP. The system tunnel provides lightning protection, thermal/aerodynamic protection, and housing for the range safety system linear shaped charge and for the OFI and DFI electrical cabling, which extends between the forward skirt connector and the aft skirt cable feed-through, with additional routing along the ET attach ring and the attach struts.

4.4.2 Network. The Structural subsystem verification network is shown in Figure 4.4.2-1.

4.4.3 Matrix. The Structural subsystem verification matrix is shown in Table 4.4.3-1.



STRUCTURAL SUBSYSTEM VERIFICATION NETWORK
FIGURE 4.4.2-1

STRUCTURAL SUBSYSTEM			SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD				
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST	
3.2.1.1.1.1	SRB/ET Attachment Loads	M30, 31, 38	M46		K41	
3.2.1.1.1.2	Separation Phase	M30, 31, 38	M46		K41	
3.2.1.1.3.2	SRB Flotation	M30, 37	K42		K42	
3.2.1.1.3.3	SRB Retrieval	M30, 31, 37	M46, 37, 38		K42	
3.2.1.1.4.1	Prelaunch	M30, 31, 37	M46, 37, 38	K40		
3.2.1.1.4.2	Launch	M30, 31, 37	M46, 37, 38		K41, 42	
3.2.1.1.4.3	Ascent	M30, 31, 37	M46, 37, 38		K41, 42	
3.2.1.1.4.4	Re-entry	M30, 31, 37	M46, 37, 38		K41, 42	
3.2.1.1.4.5.1	SRB Recovery Loads	M30, 37	M46, 37, 38		K41, 42	
3.2.1.1.4.5.2	Frustum	M30, 38	M46, 37, 38		K41, 42	
3.2.1.1.4.6.1	SRB Retrieval	M30, 37	M46, 37, 38		K42	
3.2.1.1.4.6.2	Frustum	M30, 38	M46, 37, 38		K42	
3.2.1.1.6	SRB/MLP Mating	M30, 37, 38	M37, 38	K40		
3.2.1.1.7	SRB/ET Buildup & Mating	M30, 37, 38	M37, 38	K40		
3.2.1.1.8	Stacking	M30, 37	M37, 38		K40	
3.2.1.1.9	SRB Alignment	M37	M37		K40	

TABLE 4.4.3-1

SRB VERIFICATION MATRIX					
STRUCTURAL SUBSYSTEM REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.2.1.1.10	Systems Tunnel	M30, 37	M37, 38	K40	K40
3.2.1.2.1	Nose Assembly	V7, 11, 15; M30, 32, 37, 38, 46	M37, 38, 46	M37, 38	K40, 41, 42
3.2.1.2.2	Forward Ordnance Ring	V7, 11, 13, 15; M30, 32, 37, 38 46	M37, 38, 46	M37, 38	K40, 41, 42
3.2.1.2.3	Forward Skirt	V7, 11, 15; M30, 32, 37, 46	M37, 38, 46	M37, 38	K40, 41, 42
3.2.1.2.4	Aft Skirt	V7, 11, 15; M30, 32, 37, 38	M37, 38, 46	M37, 38	K40, 41, 42
3.2.1.2.5	Mechanical Attachments	M30, 32, 37, 38, 46, 48	M37, 38, 46, 48	M37, 38	K40, 41, 42
3.2.1.2.6	Cable Tunnel	V7, 11, 15; M30, 32, 37, 38	M37, 38	M37, 38	K40, 41, 42
3.2.1.9.4	Nose Cap Separation	V3, 5, 11, 13; M30, 32, 37	V13; M37, 38	V13; K40	K41, 42
3.2.1.9.5	Reefing Line Cutter	V3, 5, 11, 13; M30, 32, 37	V13; M37, 38	V13; K40	K41, 42
3.2.1.9.6	Frustum Separation	V3, 5, 11, 13; M30, 32, 37	V13; M37, 38	V13; K40	K41, 42
3.2.1.9.8	Main Parachute Release	V3, 5, 11, 13; M30, 32, 37	V13; M37, 38	V13; K40	K41, 42
3.2.2.1.1.1	SRB Center of Gravity	V12; M30, 38	V12; M37, 38	V12; M37, 38	
3.2.2.1.1.3	SRB Recovery Center of Gravity	V12; M30, 38	V12; M37, 38	V12; M37, 38	
3.2.2.1.1.4	SRB Control Weight	V12; M30, 38	V12; M37, 38	V12, M37, 38	

STRUCTURAL SUBSYSTEM		SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.2.2.2	Mass Properties (MP) Measurements	V12; M30, 38	V12; M37, 38	V12; M37, 38	
3.2.3.2	Primary Structure, Thermal Protection Pressure Vessels	M33, 37	M37, 38	M38	K41, 42
3.2.4	Maintainability	M30, 37, 38, 46	M46	K40	K42
3.2.5.1	Useful Life	M32, 37, 38	M37, 38		K41, 42
3.2.5.2	24 Hour Notification for Launch	M38	M38		K40
3.2.5.3	Launch from Standby	M38	M38		K40
3.2.5.4	Launch Recycle	M38	M38		K40
3.2.5.5	On Pad Stay Time	M38	M38		K40
3.2.5.6	Stacking Timeline Allocation	M38			K40
3.2.6	Safety	M37			
3.2.6.1	Safety Design Preferences	M30, 34, 37	M37, 38	K40	K41, 42
3.2.6.3	Materials	M34	M37, 38	M38	K42
3.2.6.3.1	Hazardous Materials	M36, 38	M37, 38	K40	K42
3.2.6.4	Isolation of Hazardous Conditions	M37	M37, 38	K40	K42

TABLE 4.4.3-1

STRUCTURAL SUBSYSTEM		SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.2.6.8	Static Electric Protection	V30, 32, 34	M37, 38		K41, 42
3.2.6.18	Facility Grounding	M30, 37	M37, 38	K40	
3.2.6.19	Drain, Vent and Exhaust Port Design	M30, 37	M37, 38	K40	K41, 42
3.2.7.1	Natural Environments	M34	M37, 38		K41, 42
3.2.7.2	General	M34			K41, 42
3.2.7.3	Induced Environments	M34	M37, 38		K41, 42
3.2.8	Transportability/Transportation	V30, 32, 34, 37, 38	M37, 38		
3.2.8.1	Tie Down Capability	V30, 32, 34, 37, 38	M37, 38		
3.2.8.2	Integral Protection Capability	V30, 32, 34, 37, 38	M37, 38		
3.2.9.1	SRB Storage Life	M34, 38	M38		
3.3.1	Selection of Specifications and Standards	M34	M38		
3.3.2.1.1	Materials and Processes	M34, 36	M38		
3.3.2.1.2	Welding	M37, 38, 14	M38		
3.3.2.2.1	Hardware Selection	M37, 38	M38		

STRUCTURAL SUBSYSTEM			SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD				
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST	
3.3.2.2.3	Mechanical Parts Selection	V34, 36	M38			
3.3.5.1	Electromagnetic Compatibility and Lightning Protection	M30, 37, 38	M37, 38	K40	K40	
3.3.5.3	Electrical Bonding	M34	M38, 46			
3.3.5.5	Grounding and Isolation	M10, 30, 37	M37, 38, 46	K40		
3.3.6.1	Design Safety Factors	M30, 37	M37, 38			
3.3.6.2	Ultimate Combined Load	M30, 37, 38, 46	M46		K41	
3.3.6.3	Allowable Mechanical Properties	M37, 38	M37, 38			
3.3.6.4	Fracture Control	M30, 37, 38, 46	M46	M38	K41, 42	
3.3.6.5	Fatigue	M30, 37, 38, 46	M46		K41, 42	
3.3.6.6	Creep	M30, 37, 38	M46		K41, 42	
3.3.6.7	Temperature	M30, 37, 38	M37, 38		K41	
3.3.6.8	Load Conditions	M30, 37, 38, 46	M46		K41, 42	
3.3.6.9	Aeroelasticity	M30, 37	M38, 46		K41, 42	
3.3.6.10	Stress Concentration	M38	M38, 46			
3.3.6.11	Misalignment & Tolerances	M37, 38	M37, 38		K40	

TABLE 4.4.3-1

SRB VERIFICATION MATRIX					
STRUCTURAL SUBSYSTEM REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.3.6.12	Design Thickness	M37, 38	M37		K41, 42
3.3.6.13	Strength & Stiffness	M30, 37, 38	M38, 46		K41, 42
3.3.6.14	Pressurization	M30, 37, 38	M37, 38, 46		
3.3.6.15	Venting	M30, 37		K40	
3.3.6.16	Drainage	M30, 37, 38, 46	M37, 38, 46		K42
3.3.6.18	Fasteners	M36	M37		
3.3.6.18.1	Accessibility of Fasteners	M36	M37, 46	K40	
3.3.6.18.2	Screw Threads	M30, 37	M37		
3.3.6.18.3	Captive Fasteners	M30, 37	M37		K40
3.3.6.19	Flight Element Mating Design Characteristics	M30, 37	M37, 38		
3.3.6.20	Leak Protection - External Ports	M30, 37	M37, 38	K40	
3.3.8.1	Moisture Proof Enclosures	M37, 38, 46	M37, 38, 46		K42
3.3.8.2	Fungus Resistance	M36, 37	M37, 38		K42
3.3.9.1	Stress Corrosion	M30, 36, 37, 38	M38	V14; K40	K42
3.3.9.2	Corrosion Protection	M30, 36, 37, 38	M38	V14; K40	K42
3.3.10	Contamination Control	M30, 36, 38, 37	M38, 14	V14; K40	K42

STRUCTURAL SUBSYSTEM		SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CLI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.3.11	Coordinate Systems	M30, 37, 38	M37, 38		
3.3.12	Interchangeability & Replaceability	M30, 37		V37, 38	
3.3.13	Identification & Marking	M37	M14, 37	V14; K40	
3.3.13.1	Color Coding & Identification of Safety-Critical Items	M37	M14, 37	V14; K40	
3.3.13.2	Interface Identification	M37	M37, 14	V14; K40	
3.3.13.3	Element Cosmetic Coatings & Necessary Markings	M37	M14, 37	V14; K40	
3.3.13.4	Temporarily Installed Hardware Identification	M37, 14	M14, 37	V14; K40	
3.3.14	Workmanship	M36, 37, 38, 14	M14, 37	V14; K40	
3.3.15	Human Performance/ Human Engineering	M30, 37, 38	M37, 38	K40	K42
3.4	Logistics	M37	M37		
3.5	Personnel and Training	M30, 38, 46	M38	K40	K42
3.6	Interface Requirements	M37	M37	K40	

TABLE 4.4.3-1

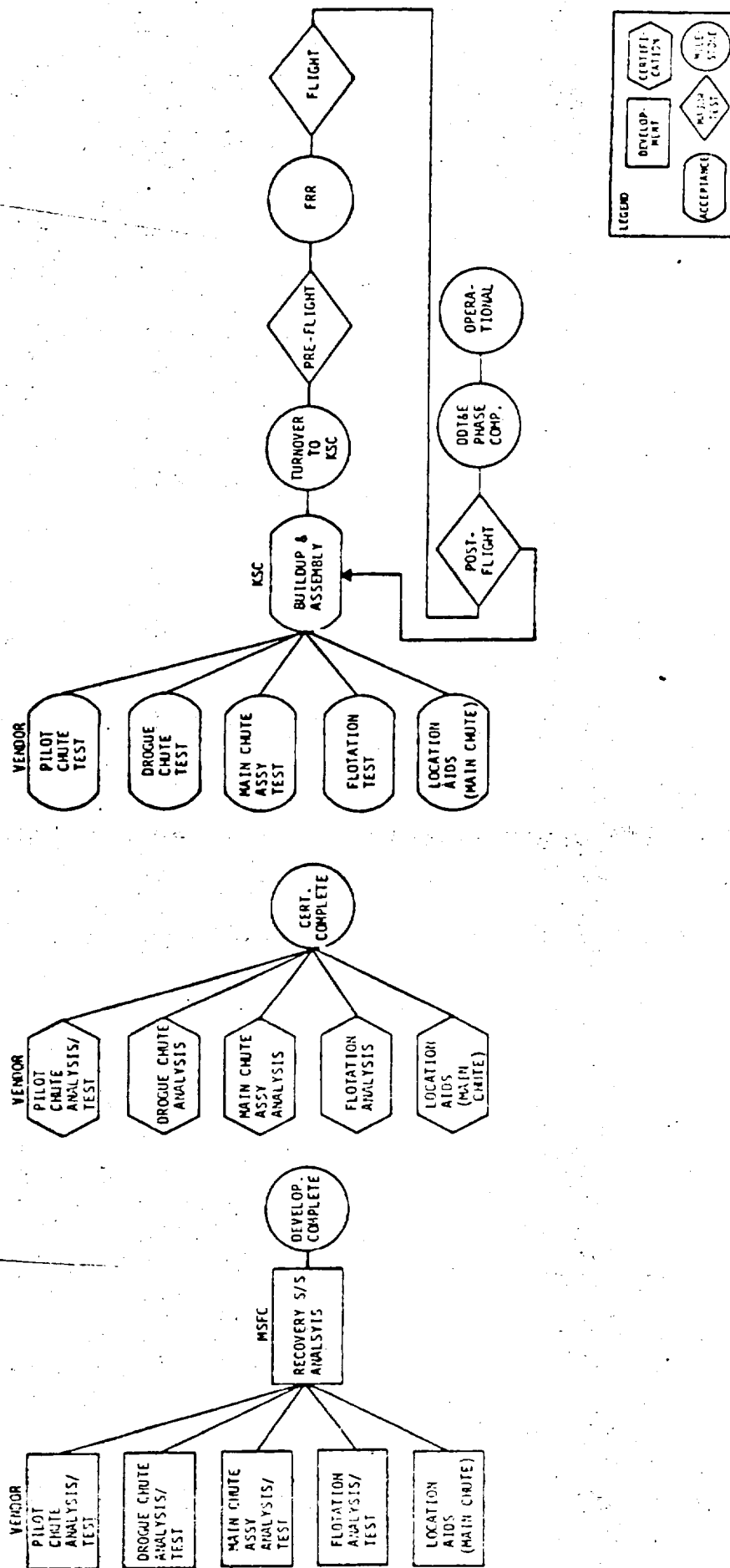
4.5 RECOVERY SUBSYSTEM

4.5.1 Description. The SRB Recovery Subsystem includes a pilot parachute, a drogue parachute and a main parachute assembly with explosive ordnance deployment devices, electronic and visual location aids, and flotation equipment. Following separation of the SRB from the ET, the recovery sequence is initiated by the separation of the nose cap from the frustum at approximately 19,000 feet by an altitude switch. This same switch also turns on the location aids (flashing lights and RF Beacon) located on the forward skirt. An altitude switch in the frustum initiates the firing of three thrusters in the frustum which blow the nose cap from the frustum deploying the pilot parachute which in turn deploys the drogue parachute. After opening, the drogue parachute stabilizes and decelerates the SRB until an altitude switch initiates separation of the frustum from the SRB forward skirt at an altitude of approximately 9,000 feet. The drogue parachute continues to support the frustum until water impact at which time a salt water activated switch turns on the frustum location aids (flashing lights and beacon). After opening through two reefing stages, the three parachutes in the main parachute assembly decelerate the SRB to a nominal water impact and are released from the SRB by a water impact switch initiated signal. A salt water activated switch turns on the main parachute location aids (flashing lights and beacon).

The location aids on the frustum, the main parachutes and the SRB will operate continuously for 72 hours to facilitate location by the ocean retrieval team. The frustum and main parachutes contain flotation material to prevent them from sinking. The SRB is maintained in a vertical position in the water by air in the sealed forward skirt compartment and air captured in the spent SRM casings.

4.5.2 Network. The recovery subsystem verification network is shown in Figure 4.5.2-1.

4.5.3 Matrix. The recovery subsystem verification matrix is shown in Table 4.5.3-1.



RECOVERY SUBSYSTEM VERIFICATION NETWORK
FIGURE 4.5.2-1

RECOVERY SUBSYSTEM		SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.2.1.1.3.1	SRB Descent	V30, 37	V37, 38		K41, 42
3.2.1.1.3.3	SKB Retrieval	V30, 37	V37, 38		K42
3.2.1.1.4.6, 7	Frustum	M30, 37	V37, 38		K42
3.2.1.4	Recovery Subsystem	M30, 37, 38	V30, 37, 38	V37, 38	
3.2.1.4.1	Nose Cap	V3, 5, 11, 13; M30, 32, 37	V13; M37, 38	V13; K40	K41, 42
3.2.1.4.2	Drogue Parachute	V30, 32, 37, 13, 14, 16	V16		K41, 42
3.2.1.4.3	Main Parachutes	V30, 32, 37, 13, 14, 16	V16		K41, 42
3.2.1.4.4	Parachute Equipment Reuse	V32, 37, 38	M37, 38		K41, 42
3.2.1.4.5	Flotation Equipment	V30, 37	V37, 38		K42
3.2.1.4.6	Location Aids - see 3.2.1.5.10	V1, 3, 5, 6, 16; M30, 32, 37	V1, 3, 5, 6	V1	K42
3.2.1.4.7	Design Safety Factors	V11, 16; M30, 32, 37	V11, 16		K42
3.2.1.4.8	Temperature Constraints	V1, 3, 5, 6; M30, 32, 37	V1, 3, 5, 6	V1	K42
3.2.4	Maintainability	V37	M38		K42
3.2.5.1	Useful Life	V37, 38, 32, 16, 11	M37, 38		K41, 42
3.2.6	Safety	V37			
3.2.6.1	Safety Design Preferences	V30, 34, 37	V37, 38	K40	K41, 42

TABLE 4.5.3-1

RECOVERY SUBSYSTEM			SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD				
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST	
3.2.6.3	Materials	V34	V37, 38	V38	K42	
3.2.6.3.1	Hazardous Materials	V36, 38	V37, 38	K40	K42	
3.2.6.4	Isolation of Hazardous Conditions	V37	V37, 38	K40	K42	
3.2.6.5	Protection of Critical Functions	V30, 37	V13; M38	V13; K40	K41, 42	
3.2.6.7	Range Safety Requirements	V30, 37	V13; M38	V13; K40	K41, 42	
3.2.6.9	System Protection During Separation	M30, 32, 37	M37	M38	K41, 42	
3.2.6.11	Contamination	V30, 36, 37	M38	K40, 14	K42	
3.2.6.12	Cross Contamination	V30, 13, 37	M38	M38	K41, 42	
3.2.6.14	Arming/Disarming Explosives	V30, 13, 37	M38	K40		
3.2.7.1	Natural Environments	M34	M37, 38		K41, 42	
3.2.7.2	General	M34	M37, 38		K41, 42	
3.2.7.3	Induced Environments	M34	M37, 38		K41, 42	
3.2.8	Transportability/Transportation	V30, 32, 34, 37, 38	M37, 38			
3.2.8.1	Tie Down Capability	V30, 32, 34, 37, 38	M37, 38			

TABLE 4.5.3-1

RECOVERY SUBSYSTEM		SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.2.8.2	Integral Protection Capability	V30, 32, 34, 37, 38	M37, 38		
3.2.9.1	SRB Storage Life	M34, 38	M38		
3.3.1	Selection of Specifications and Standards	M34	M38		
3.3.2.1.1	Materials and Processes	M34, 36	M38		
3.3.2.1.4	Pyrotechnics	V3, 5, 11, 13; M30, 32, 37,	V13	V13; K40	
3.3.2.2.1	Hardware Selection	M37, 38	V38		
3.3.2.2.2	Electrical/Electronic & Electromechanical (EEE)	V34, 36	V38		
3.3.2.2.2.1	Switching Devices	V34, 36	V38		
3.3.2.2.3	Mechanical Parts Selection	V34, 36	V38		
3.3.5.1	Electromagnetic Compatibility and Lightning Protection	V30, 37, 38	V37, 38	K40	K40
3.3.5.3	Electrical Bonding	M34	V38		
3.3.5.4	Soldering	V14	V14	V14	
3.3.5.5	Grounding and Isolation	M10, 30, 37	V37, 38	K40	

TABLE 4.5.3-1

RECOVERY SUBSYSTEM			SRB VERIFICATION MATRIX			
REQUIREMENTS			VERIFICATION PHASE/LOCATION/METHOD			
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST	
3.3.5.12	Protection of Electrical and Electronic	V30, 34, 37	V37, 38	K40		
3.3.5.15	Improper and/or Cross Connection Prevention	V30, 32, 37	V37, 38	K40		
3.3.5.16	Wire and Cable Installations	V30, 37, 38	V37, 38	K40		
3.3.8.2	Fungus Resistance	V36, 38	V37, 38			
3.3.9.1	Stress Corrosion	V30, 36, 37, 38	V38	V14; K40	K42	
3.3.9.2	Corrosion Protection	V30, 36, 37, 38	V38	V14; K40	K42	
3.3.10	Contamination Control	V30, 36, 37, 38	V14, 38	K14, 40	K42	
3.3.12	Interchangeability & Replaceability	V30, 37	V37, 38	V37, 38		
3.3.13	Identification & Marking	V37	V37	V14; K40		
3.3.13.1	Color Coding & Identification of Safety Critical Items	V37	V14, 37	V14; K40		
3.3.13.2	Interface Identification	V37	V14, 37	V14; K40		
3.3.13.3	Element Cosmetic Coating & Necessary Markings	V37	V14, 37	V14; K40		

TABLE 4.5.3-1

RECOVERY SUBSYSTEM		SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.3.13.4	Temporarily Installed Hardware Identification	V37	V14, 37	V14; K40	
3.3.14	Workmanship	V36, 37, 38, 14	V14, 37	V14; K40	
3.3.15	Human Performance/ Human Engineering	V30, 37, 38	V37, 38		
3.4	Logistics	M37	M37		
3.5	Personnel and Training	M30, 38	M38	K40	K42
3.6	Interface Requirements	M37	M37	K40	

TABLE 4.5.3-1

4.6 SEPARATION SUBSYSTEM

4.6.1 Description. The Separation Subsystem includes four ordnance-actuated separation bolts that allow SRB separation from the ET and eight solid Booster Separation Motors (BSM) that provide the separation forces to translate the SRB away from the ET/Orbiter. The four separation bolts are located, one in the forward attach point and three in the aft attach struts, between the SRB and ET. The eight BSM's are mounted four on the frustum and four on the aft skirt.

Separation of the SRB from the Orbiter/ET is initiated by hardwire command from the Orbiter to the SRB Integrated Electronic Assembly after SRB burnout. Activation of the four separation bolts and the eight separation motors for each SRB is initiated simultaneously by redundant separation signals from the SRB IEA's, which will be sent to each of the SRB/ET attach points and to each of the SRB frustum and aft skirt BSM's.

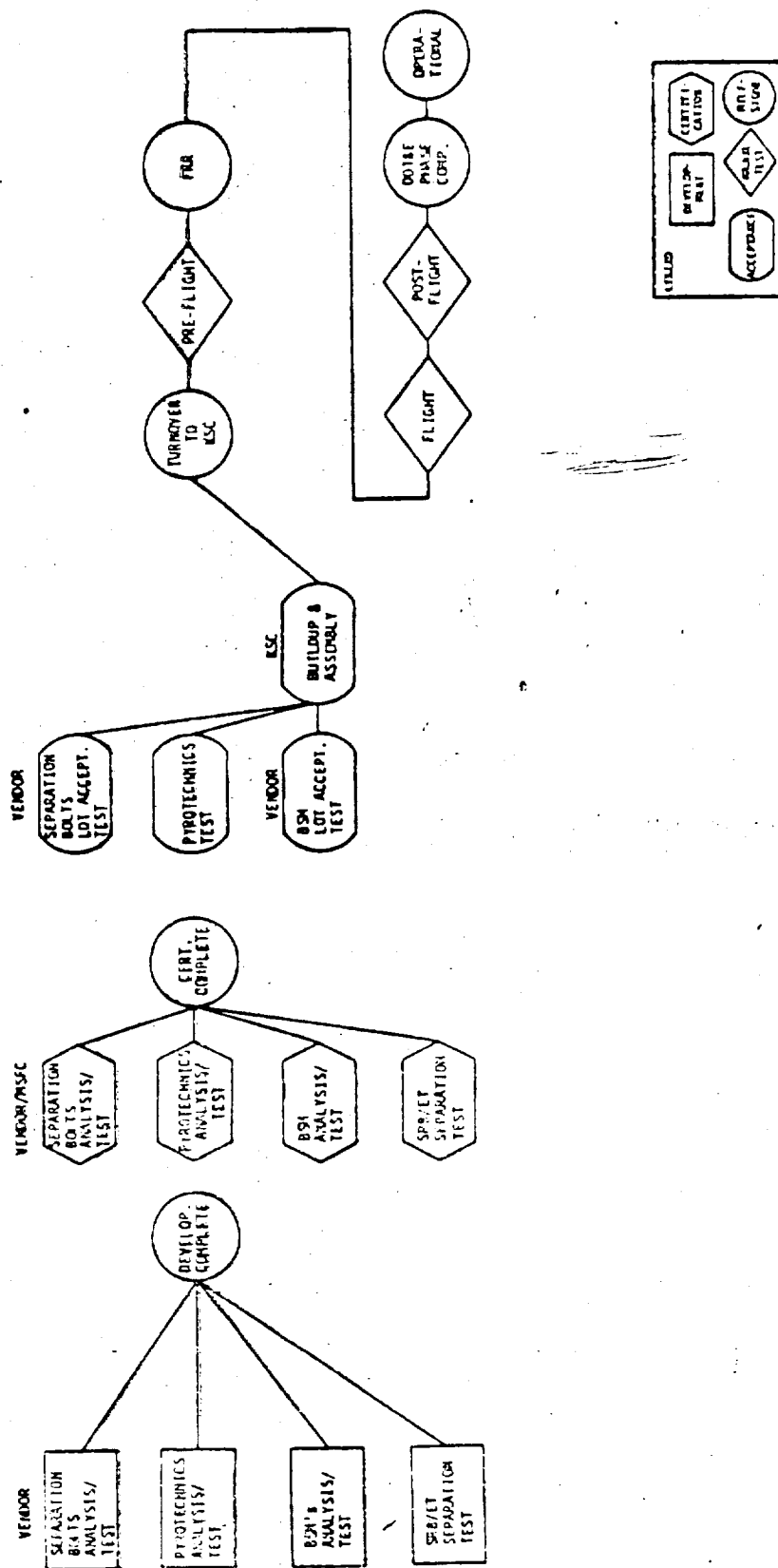
The separation signals from the SRB IEA's to the SRB/ET attach points initiate two redundant Standard Manned Spaceflight Initiator (SMSI) pressure cartridges at each attach point.

The separation signals to the Booster Separation Motors (BSM) located in the frustum initiate redundant SMSI detonators which are mounted on separate CDF manifolds. The CDF manifolds are linked to the BSM by means of the CDF assemblies and initiators. An identical ordnance chain is provided for the BSM's located on the aft skirt.

Electrical disconnect between the SRB and the ET is accomplished by pull-away connectors located on the SRB aft struts.

4.6.2 Network - The Separation subsystem verification network is shown in Figure 4.6.2-1.

4.6.3 Matrix - The Separation subsystem verification matrix is shown in Table 4.6.3-1.



SEPARATION SUBSYSTEM VERIFICATION
NETWORK
FIGURE 4.6.2-1

SRB VERIFICATION MATRIX				
SEPARATION SUBSYSTEM		VERIFICATION PHASE/LOCATION/METHOD		
REQUIREMENTS		DEVELOPMENT	CERTIFICATION	ACCEPTANCE
CEL NO.	TITLE			
3.2.1.1.2	Separation Phase	M30, 37, 48	M38, 48	M37, 38
3.2.1.1.5	Shuttle Flight Vehicle Checkout	M30, 38	M37, 38	K40
3.2.1.1.7	SRB/ET Buildup & Mating	M30, 37, 38	M37, 38	K40
3.2.1.3	Separation Subsystem	V1, 3, 5, 6, 13; M30, 32, 37, 38	V13, M37, 38	V1
3.2.1.3.1	Configuration	M30, 37, 38	M37, 38	K40
3.2.1.3.2	Booster Separation	V1, 3, 5, 6, 13; M30, 32, 37, 38	V13; M37, 38	V13; K40
3.2.1.9.2	SRB/ET Separation	V3, 5, 11, 13, 48	V13; M37, 38, 48	V3; K40
3.2.1.9.3	Separation Motor Ignition	V3, 5, 11, 13; M30, 32, 37	V1, M37, 38	V3; K40
3.2.3.1	Flight Vehicle Sub-system Functional Reliability	V33, 37	V13; M37, 38	V37, 38
3.2.3.3	Redundancy Verification	V33, 37	M37	K40
3.2.4	Maintainability	M30, 37, 38	M37, 38	K42
3.2.5.1	Useful Life	V32, 37, 38	M37, 38	K42
3.2.5.2	24 Hour Notification for Launch	M38	M38	K40

TABLE 4.6.3-1

SEPARATION SUBSYSTEM			SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD				
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST	
3.2.5.3	Launch from Standby	M38	M38		K40	
3.2.5.4	Launch Recycle	M38	M38		K40	
3.2.5.5	On Pad Stay Time	M38	M38		K40	
3.2.6	Safety	V37				
3.2.6.1	Safety Design Preferences	V30, 34, 37	V37, 38	K40	K41, 42	
3.2.6.3	Materials	V34	V37, 38	V38	K42	
3.2.6.3.1	Hazardous Materials	V36, 38	V37, 38	K40	K42	
3.2.6.4	Isolation of Hazardous Conditions	V37	V37, 38	K40	K42	
3.2.6.5	Protection of Critical Functions	V30, 13, 37	V13;M38	V13; K40	K41, 42	
3.2.6.7.	Range Safety Requirements	V30, 13, 37	V13; M38	V13; K40	K41, 42	
3.2.6.8	Static Electric Protection	V30, 32, 34	M37, 38		K41, 42	
3.2.6.9	System Protection During Separation	M30, 32, 37	M37	M38	K41, 42	
3.2.6.11	Contamination	V30, 36, 37	M38	V14; K40	K42	
3.2.6.12	Cross Contamination	V30, 13, 37, 38	V13; M37, 38	M38	K41, 42	
3.2.6.14	Arming/Disarming Explosives	V30, 13, 37	M38	K40		

TABLE 4.6.3-1

SEPARATION SUBSYSTEM		SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CLI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.2.6.15	Separation of Critical Functions	V30, 13, 34, 37, 48	M37, 38, 48	K40	
3.2.6.16	Protection of Redundant Components	V30, 13, 34, 37, 48	M37, 38, 48		
3.2.6.17	Isolation of Subsystem Anomalies	V30, 13, 34, 37, 48	M37, 38, 48		
3.2.7.1	Natural Environments	M34	M37, 38		K41, 42
3.2.7.2	General	M34	M37, 38		K41, 42
3.2.7.3	Induced Environments	M34	M37, 38		K41, 42
3.2.8	Transportability/Transportation	V30, 32, 34, 37, 38	M37, 38		
3.2.8.1	Tie Down Capability	V30, 32, 34, 37, 38	M37, 38		
3.2.8.2	Integral Protection Capability	V30, 32, 34, 37, 38	M37, 38		
3.2.9.1	SRB Storage Life	M34, 38	M38		
3.3.1	Selection of Specifications and Standards	M34	M38		
3.3.2.1.1	Materials and Processes	M34, 36	M38		
3.3.2.1.2	Welding	M14			

TABLE 4.6.3-1

SEPARATION SUBSYSTEM REQUIREMENTS			SRB VERIFICATION MATRIX			
REQUIREMENTS			VERIFICATION PHASE/LOCATION/METHOD			
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST	
3.3.2.1.4	Pyrotechnics	V3, 5, 11, 13; M30, 32, 37	V13	V13; K40	K40	
3.3.2.2.1	Hardware Selection	M37, 38	V38			
3.3.2.2.3	Mechanical Parts Selection	V34, 36	V38			
3.3.5.1	Electromagnetic Compatibility and Lightning Protection	V30, 37, 38	V37, 38	K40		
3.3.5.4	Soldering	V14	V14	V14		
3.3.5.5	Grounding and Isolation	M10, 30, 37	V37, 38	K40		
3.3.5.15	Improper and/or Cross Connection Prevention	V30, 32, 37	V37, 38	K40		
3.3.8.2	Fungus Resistance	V36, 38	V37, 38			
3.3.9.1	Stress Corrosion	V30, 36, 37, 38	V38	V14; K40		
3.3.9.2	Corrosion Protection	V30, 36, 37, 38	V38	V14; K40		
3.3.10	Contamination Control	V30, 36, 37, 38	V14, 38	V14; K40		
3.3.12	Interchangeability & Replaceability	V30, 37	V37, 38	V37, 38		
3.3.13	Identification & Marking	V37	V37	V14, K40		

TABLE 4.6.3-1

SEPARATION SUBSYSTEM		SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.3.13.1	Color Coding & Identification of Safety-Critical Items	V37, 38	V14, 37	V14, K40	
3.3.13.2	Interface Identification	V37	V14, 37	V14, K40	
3.3.13.3	Element Cosmetic Coatings & Necessary Markings	V30, 37, 38	V14, 37	V14; K40	
3.3.13.4	Temporarily Installed Hardware Identification	V37	V14, 37	V14; K40	
3.3.14	Workmanship	V36, 37, 38, 14	V14	V14; K40	
3.3.15	Human Performance/ Human Engineering	V30, 37, 38	V37, 38		
3.4	Logistics	M37	M37		
3.5	Personnel and Training	M30, 38	M38	K40	K42
3.6	Interface Requirements	M37	M37	K40	

TABLE 4.6.3-1

4.7 SOLID ROCKET MOTOR SUBSYSTEM

4.7.1 Description - The Solid Rocket Motor (SRM) subsystem for each SRB is made up of a forward motor segment, two center motor segments, and an aft motor segment. Each motor segment consists of a cylindrical, weld-free case with clevis-type mechanical joints, liners, insulation, and propellant. The forward motor segment interfaces with the SRB forward skirt and includes the ignitor, initiators and a safe and arm device. The aft motor segment, which mates to the SRB aft skirt, provides for mounting of the movable nozzle to which the TVC actuators are attached. The aft motor segment has provisions for installing the ET attach ring and the four cavity collapse rings. In the stacked configuration, the SRB external cables and system tunnel are attached to and routed along the outside of the SRM segments. Mounting of various operational and development instrumentation transducers is provided at strategic locations on the SRM.

4.7.2 Network - The SRM subsystem verification network is shown in Figure 4.7.2-1.

4.7.3 Matrix - The SRM subsystem verification matrix is shown in Table 4.7.3-1.

SRM SUBSYSTEM			SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD				
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST	
3.2.1.1.4.1	Prelaunch	T30, 31, 37	M46; T37, 38	K40		
3.2.1.1.4.2	Launch	T30, 31, 37, 45	T37, 38, 45; M46		K41, 42	
3.2.1.1.4.3	Ascent	T30, 31, 37, 45	T37, 38, 45; M46		K41, 42	
3.2.1.1.4.4	Re-Entry	T30, 31, 37	M46; T37, 38		K41, 42	
3.2.1.1.4.5	SRB Recovery Loads	T30, 31, 38, 46	M46, 37, 38		K41	
3.2.1.1.7	SRB/ET Buildup & Mating	T30, 37, 38, 45	T37, 38, 45	K40		
3.2.1.1.8	Stacking	T30, 37	T37	K40		
3.2.1.6.1	Performance	T30, 35, 38, 45	T45		K41	
3.2.1.6.2.1	Ignition Transient	T30, 35, 38, 45	T45		K41	
3.2.1.6.2.2	SRM Performance Characteristics	T30, 35, 38, 45	T45		K41	
3.2.1.6.2.2.1	Thrust Vector	T30, 35, 38, 45	T45		K41	
3.2.1.6.2.2.2	Thrust Differential	T30, 35, 38, 45	T45		K41	
3.2.1.6.2.2.3	Matched Pair Variation	T30, 35, 38, 45	T45		K41	
3.2.1.6.3	Case	T30, 31, 37	M46			
3.2.1.6.4.1	Nozzle Exit Cone	T30, 13, 37	T38		K41, 42	
3.2.1.6.4.2	Nozzle Torque	T30, 38, 45	T45		K41	
3.2.1.6.5	Ignition	T30, 13, 37, 45	T45	K40	K41	

SRM SUBSYSTEM		SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.2.1.6.5.1	Electro-Mechanical S&A Device	T30, 13, 37, 45	T45	K40	K41, 42
3.2.1.6.6	Design Loads	T30, 31, 38	M46		
3.2.1.6.7	SRM Interfaces See 3.6.2	T30, 37	M46	K40	
3.2.1.6.8	Interchangeability	T30, 37			K41
3.2.1.6.9	Storage and Transportation	T38			
3.2.1.9.1	SRB Ignition See 3.2.1.6.5	T3, 5, 32, 34, 37, 45 V3, 5, 13; M34, 37	V13; T37, 38, 45; M37, 38	V13; K40	
3.2.1.9.7	Nozzle Exit Cone Extension Release	V3, 5, 13; T3, 5, 32	V13; M37, 38; T37, 38	V13; K40	K41, 42
3.2.2.1	Mass Properties	T30, 38			
3.2.2.1.1.2	SRM Center of Gravity	T30, 38	T12		
3.2.2.1.1.5	SRB Propellant Weight	T30, 38	T12, 38		T12
3.2.2.2	Mass Properties (MP) Measurements	T30, 38	T12		
3.2.2.3	SRB Size	T30, 37			
3.2.3.1	Flight Vehicle Sub-system Functional Reliability	T33, 45	T37, 38		

TABLE 4.7.3-1

SRM SUBSYSTEM		SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.2.3.2	Primary Structure, Thermal Protection, Pressure Vessels	T33, 45	T45		K42
3.2.3.3	Redundancy Verification	T33, 37, 45	T37, 38	K40	K41, 42
3.2.4	Maintainability	T30, 34, 36, 37, 38, 45	T37, 38, 45	K40	K42
3.2.5.1	Useful Life	T37, 38			
3.2.5.6	Stacking Timeline Allocation	T38			
3.2.6	Safety	T38			
3.2.6.1	Safety Design Preferences	T30, 37, 45	T37, 38	K40	K41, 42
3.2.6.3	Materials	T34, 45	T37, 38		K42
3.2.6.3.1	Hazardous Materials	T36, 38	T37, 38		
3.2.6.4	Isolation of Hazardous Conditions	T37	T37, 38		
3.2.6.5	Protection of Critical Functions	T30, 37	T45	K40	K41, 42
3.2.6.7	Range Safety Requirements	T30, 13, 37, 45	T45	K40	K42
3.2.6.8	Static Electric Protection	T30, 37, 45	T45	K40	

TABLE 4.7.3-1

SRM SUBSYSTEM		SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.2.6.10	Ordinance and/or Pyrotechnic Safety	T30, 13, 37, 45	T13, 37, 38, 45	T13; K40	
3.2.6.11	Contamination	T30, 36, 37	T38	T14; K40	
3.2.6.12	Cross Contamination	T30, 13, 37, 45	T45		K41
3.2.6.13	Safe and Arm	T30, 37, 45	T45	K40	
3.2.6.14	Arming/Disarming Explosives	T30, 13, 37, 45	T45	K40	
3.2.6.15	Separation of Critical Functions	T30, 13, 37, 45	T45	K40	
3.2.6.16	Protection of Redundent Components	T30, 13, 37, 45	T45	K40	
3.2.6.17	Isolation of Subsystem Anomalies	T45	T37, 38, 45	K40	K41, 42
3.2.7.1	Natural Environments	T30, 31, 37, 38, 45; M7	T45, 46		K41, 42
3.2.7.2	General	T30, 37, 38			K41, 42
3.2.7.3	Induced Environments	T30, 31, 37, 38, 45; M7	T45, 46		K41, 42
3.2.8	Transportability/Transportation	T30, 32, 34, 37, 38	T37, 38		
3.2.8.1	Tie Down Capability	T30, 32, 34, 37, 38	T37, 38		
3.2.8.2	Integral Protection Capability	T30, 32, 34, 37, 38	T37, 38		
3.2.9.2	SRM Storage Life	T38	T38		

TABLE 4.7.3-1

SRM SUBSYSTEM		SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
REF NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.3.1	Selection of Specifications and Standards	T37, 38			
3.3.2.1.1	Materials and Processes	T37, 38	M36, 37, 38		
3.3.2.1.2	Welding	T37	M38	T14; M14	
3.3.2.1.3	Castings	T37, 38			
3.3.2.1.4	Pyrotechnics	V3, 5, 11, 13; M30, 32, 37	V13	V13; K40	
3.3.2.2.1	Hardware Selection	T30, 35, 36, 37, 38			
3.3.2.2.2	Electrical/Electronic & Electromechanical (EEE)	T34, 36	T38		
3.3.2.2.2.1	Switching Devices	T34, 36	T38		
3.3.2.2.3	Mechanical Parts Selection	T30, 35, 36, 37, 38	T38		
3.3.5.1	Electromagnetic Compatibility and Lightning Protection	T45	T37, 38, 45	K40	
3.3.5.3	Electrical Bonding	T34			
3.3.5.4	Soldering	T14	T14	T14	
3.3.5.5	Grounding and Isolation	T10, 45	T37, 38, 45	K40	
3.3.6.1	Design Safety Factors	T37			

SRM SUBSYSTEM		SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.3.6.2	Ultimate Combined Load	T30, 37, 38, 45	M46; T45		K41
3.3.6.3	Allowable Mechanical Properties	T37, 38			
3.3.6.4	Fracture Control	T30, 37, 38, 45	M46; T45		K41, 42
3.3.6.5	Fatigue	T30, 37, 38, 45	M46; T45		K41, 42
3.3.6.6	Creep	T30, 37, 38, 45	M46; T45		K41, 42
3.3.6.7	Temperature	T30, 37, 38, 45	T45		
3.3.6.8	Load Conditions	T30, 37, 38, 45	M46; T45		K41, 42
3.3.6.9	Aeroelasticity	T37	M46		K41, 42
3.3.6.10	Stress Concentration	T38	M46; T45		
3.3.6.11	Misalignment & Tolerances	T37, 38			K40
3.3.6.12	Design Thickness	T37, 38			
3.3.6.13	Strength & Stiffness	T30, 37, 38, 45	M46; T45		K41, 42
3.3.6.14	Pressurization	T30, 37, 38, 45	M46; T45		K41, 42
3.3.6.15	Venting	T30, 37, 45	T45	K40	
3.3.6.16	Drainage	T30, 37, 45	T45	K40	
3.3.6.18	Fasteners	T36			

TABLE 4.7.3-1

SRM SUBSYSTEM		SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.3.6.18.1	Accessibility of Fasteners	T30, 37, 45	T45	K40	
3.3.6.18.2	Screw Threads	T36			
3.3.6.18.3	Captive Fasteners	T30, 37			
3.3.8.2	Fungus Resistance	T36, 38			
3.3.9.1	Stress Corrosion	T30, 36, 37; M36, 37	T38; M38	T13; K40	
3.3.9.2	Corrosion Protection	T30, 36, 37	T38	T14; K40	
3.3.10	Contamination Control	T30, 36, 37	T38	T14; K40	
3.3.12	Interchangeability & Replaceability	T30, 37			
3.3.13	Identification & Marking	T37, 38	T14	T14; K40	
3.3.13.1	Color Coding & Identification of Safety-Critical Items	T37, 38	T14	T14; K40	
3.3.13.2	Interface Identification	T37	T14	T14; K40	
3.3.13.3	Element Cosmetic Coatings & Necessary Markings	T37, 38	T14	T14; K40	
3.3.13.4	Temporarily Installed Hardware Identification	T37	T14	T14; K40	
3.3.14	Workmanship	T36, 37, 38	T14	T14; K40	

TABLE 4.7.3-1

SRM SUBSYSTEM		SRB VERIFICATION MATRIX			
REQUIREMENTS		VERIFICATION PHASE/LOCATION/METHOD			
CEI NO.	TITLE	DEVELOPMENT	CERTIFICATION	ACCEPTANCE	MAJOR TEST
3.3.15	Human Performance/ Human Engineering	M/T30			
3.4	Logistics	M37	M37		
3.5	Personnel and Training	M30, 38	M38	K40	K42
3.6	Interface Requirements	M37	M37		

TABLE 4.7.3-1

5.0 ELEMENT VERIFICATION

5.1 MANUFACTURING ASSEMBLY AND CHECKOUT. Final manufacturing assembly and checkout activities will take place following the SRB component level acceptance tests at the hardware suppliers' facilities and delivery of the subsystem components to the Booster Manufacturing, Assembly, and Refurbishment Facility at KSC. These activities involve the installation of the flight hardware into the forward skirt, buildup of the nose assembly, assembly of the aft skirt and the installation of the TVC subsystem into the aft skirt. A final manufacturing checkout of the subsystems installed in the nose assembly, forward skirt and aft skirt using the LPS and software developed during EIVT at MSFC will verify that the SRB subsystems performance conforms to the design requirements. The primary objective of this phase of manufacturing and checkout is to demonstrate that the subsystems are properly assembled per the applicable drawings and specifications, and that they, in conjunction with the software and human elements, will function as integrated subsystems in all modes. This final manufacturing checkout constitutes subsystem level verification of flight hardware assembled to this point in element buildup prior to turnover to KSC for continuing buildup/assembly activities.

5.2 BOOSTER ASSEMBLY BUILDUP. Booster assembly buildup concerns the activities involved with mating the forward and aft SRM segments to the forward and aft SRB skirts. It also includes installing flight hardware that was not installed during final manufacturing assembly and culminates with the flight hardware being assembled to the Booster Assembly level (an Aft Booster Assembly and a Forward Booster Assembly) ready for stacking on the MLP.

5.3 ELEMENT STACKING AND PREFLIGHT CHECKOUT (SRB PRELAUNCH OPERATIONS)

5.3.1 Receiving Operations. A visual inspection of the SRB will be conducted to identify any damage incurred during transportation to the VAB. Critical areas of inspection are the BSM nozzles in the forward and aft skirts, SRB/ET/Orbiter mechanical and electrical attachment points, altitude plenum outlets, and TVC subsystem. This operation will serve as a partial verification of the associated transportation equipment.

5.3.2 Stacking Operations. The final phase of SRB buildup and checkout will take place on the MLP in the VAB where the aft, two center, and forward booster assemblies will be stacked to form a complete SRB element. During the stacking of an SRB (mating of the booster assemblies), decay checks will be performed to demonstrate assembly interface seal integrity.

After two SRB's have been stacked and electrically checked with the external cables, tunnels, and aft attach struts installed, both SRB's will be interconnected with the LPS, STE and the TVC Service and Checkout Console.

5.3.3 Checkout. Prior to mating the SRB's to the external tank, an integrated end-to-end functional checkout of the E&I subsystem, TVC subsystem, and SRM nozzle will verify launch readiness of the two SRB's. This simulated flight test will verify all sequence-critical functions.

5.4 SRB/ET/ORBITER MATE AND CHECKOUT. Following the integrated checkout of the two SRB's, the ET will be hoisted between and mated to the SRB's. The mechanical and electrical interfaces will be verified by inspection and continuity tests. After the Orbiter is mated to the ET, interface verification and integrated system verifications will be performed using the LPS to control and monitor the Orbiter systems functions. The objectives of the interface checkout are to (1) verify that the assembly operations were performed properly, (2) verify that functional paths disturbed by these operations have been reestablished, and (3) verify the integrity of the interfaces which were connected for the first time.

5.5 FLIGHT READINESS REVIEWS. The SRB Project Manager will conduct an element Flight Readiness Review prior to the Shuttle System Flight Readiness Review for each vehicle to be utilized in the Vertical Flight Test Program. The purpose of these reviews is to certify the acceptability of the SRB for flight test and to evaluate its readiness to achieve all test objectives.

MSFC will support the Shuttle System Flight Readiness Reviews with cognizant personnel and appropriate SRB FRR information and documentation. MSFC will assure that its contractors adequately provide support for the reviews and will assure that immediate action will be taken to correct any discrepancies.

5.6 FLIGHT AND POST-FLIGHT VERIFICATION

5.6.1 Vertical Flight. The Vertical Flight Test program and the turnaround activities associated with it constitute the final phase of SRB element verification and will demonstrate the total vehicle performance under actual flight conditions. The performance requirements defined in Shuttle System MVP, Volume X, Master Flight Assignment Document, will be verified. The mission characteristics associated with pre-launch, launch, boost, separation, recovery, retrieval and maintenance turnaround will be evaluated and verified. Data derived from the E&I subsystem DFI and OFI during the DDT&E flights will be used to verify the operational performance of the SRB.

5.6.1.1 Recovery and Retrieval. The first full scale operational test and evaluation of the SRB Recovery subsystem and final perfection of retrieval techniques and systems will take place during the VFT program. (KSC is responsible for verification of the retrieval techniques and systems.) During these flights, some load and stress analyses will be tested and evaluated. In addition, the following functions and requirements will be verified:

1. Nose cap jettison
2. Frustum separation
3. Parachute deployment
4. Parachute reefing
5. Parachute disconnects
6. Flotation equipment
7. Location aids
8. Nozzle extension severance
9. Ability of retrieval vessels to locate SRBs
10. Ability to change the SRB attitude from vertical to horizontal for towing
11. Parachute retrieval
12. Frustum retrieval
13. Towing operations
14. Docking operations

5.6.1.2 Refurbishment During DDT&E. After SRB disassembly during the DDT&E phase of the Shuttle program, the subassemblies will be returned to the Booster Manufacturing, Assembly, and Refurbishment Facility, to be processed in accordance with procedures developed for the operational/DDT&E phase. In addition, the operational flight E&I, TVC, and SRM subsystems components, excluding throw-away equipment, will be returned to the responsible vendor for more detailed analyses and test. These tests/analyses will consist of receiving inspection, acceptance test, component disassembly to the SRU level for inspection/test as applicable, component reassembly, and acceptance test. During these operations, the quality control imposed upon the vendor will apply. Any variation in performance parameters from those previously recorded will be logged and a determination made as to whether redesign, refurbishment, or no further action is required. These tests and analyses are required as a part of the total verification of the maintainability and design of the component.

5.7 MAJOR GROUND TESTS. The major ground tests identified in the following paragraphs will be conducted under simulated conditions to verify that the SRB will perform its intended function. These tests will verify the contract end item specification and the Interface Control Documents requirements, and will also verify the performance of integrated subsystems and combined elements prior to initiation of the development flights.

5.7.1 Static Structural Tests. The SRB Static Structural Tests will determine the ability of structures to withstand predicted or measured static forces which may be encountered in assembly, storage, transportation, handling, testing, flight, recovery, and turnaround maintenance activities. The tests will also verify materials selection, validate stress analysis and design margins, and verify structural integrity for critical design limit and ultimate loads.

5.7.1.1 Test Configuration and Subsystems Components Involved. The Static Structural Test involves the SRB structural subsystem and SRM subsystem and is to be accomplished through a total of eight basic test set-ups, simulating the load conditions in the SRB service life. Test configurations for the SRB short stack tests and for structural component testing are described in the following paragraphs.

5.7.1.1.1 SRB Short Stack Configuration. Test hardware and fixtures for the short stack phase of the structural testing provide for simulating all critical load conditions experienced by the SRB during its normal service life. The following three test set-ups, which are defined in detail in the SRB Structural Test and Instrumentation Requirements Document, have been established to accomplish this objective.

5.7.1.1.1.1 Test Set-Up I. In this configuration the short SRB, which is structurally a flight type vehicle with four center motor-case segments eliminated for economy, is positioned with its longitudinal axis horizontal, allowing application of loads to the frustum, forward skirt, and forward segment of the motor case to simulate pre-launch, launch, flight, separation and drogue chute loads. The capability exists for application of internal pressure in either or both the forward skirt and the motor case, and for application of concentrated loads at selected points. Internal pressures shall be applied only with the forward skirt and/or motor case filled with transformer oil.

5.7.1.1.1.2 Test Set-Up II. Following completion of testing associated with the first test configuration, the frustum is removed, and provisions are made for application of loads to the main chute attach points on the forward skirt. The capability also exists in this configuration for pressurization of the forward skirt, and for loading of the forward bulkhead to simulate towback conditions. In this test configuration, the short SRB is again positioned with its longitudinal axis horizontal.

5.7.1.1.1.3 Test Set-Up III. The short SRB is positioned again with its longitudinal axis horizontal, and the flight-type forward skirt is replaced with a dummy forward skirt. This test configuration then allows the application of loads simulating the effects of the pre-launch launch, flight and separation load environments on the aft portion of the SRB. Test loads are applied at the forward end of the forward skirt, the aft ET attach points, the aft skirt actuator attach points, and the aft skirt separation motor attach points.

5.7.1.1.2 Structural Component Testing. Five structural components tests will be conducted as a part of the static structural test program. These tests are defined to provide more accurate simulation of critical loads than is possible in the short stack testing described in paragraph 5.7.1.1 above. Test set-ups associated with this component testing will be defined in detail in the Static Structural Test Requirements Document and are described briefly in the following paragraphs.

5.7.1.1.2.1 Aft Structural Components. The test configuration contains the capability for imposing varying pressures on the aft bulkhead and aft skirt to simulate the pressures these components will experience at initial water impact. In addition, the capability exists for loading the ET attach ring and aft attach struts with water impact loads.

5.7.1.1.2.2 Frustum. The capability is provided in this test configuration for simulating on the frustum the drogue chute inertia forces occurring during flight, deployed drogue chute forces, main chute deployment forces, and distributed pressures occurring during water impact.

5.7.1.1.2.3 Nose Cap. This test configuration provides the capability for application of a system of loads to simulate the thruster and drogue chute deployment loads on the flight nose cap. Nose cap testing will allow imposition of pressure forces on assembly surface area in combination with other loads.

5.7.1.1.2.4 Cable Tunnel. The systems cable tunnel is tested in this component test set-up through application of loads to simulate the loading environment experienced in SRB water impact.

5.7.1.1.2.5 Heat Shield. This test set-up provides the capability for testing the curtain heat shield to simulate the maximum pressures and the temperatures the shield will experience during its nominal life.

5.7.1.2 Objectives. The SRB Static Structural testing will involve structural component testing and testing of the short SRB configuration. The primary objective of this testing is to verify the structural integrity of the SRB for its critical design loads and environments and to verify its normal service life. Specifically, these objectives are as follows:

- a. Demonstrate the static structural strength and service life of the SRB when subjected to critical design loads.
- b. Determine deflection influence coefficients of attach and holddown points for structural and functional characteristics.
- c. Verify internal load distribution.
- d. Identify design deficiencies.

Specific verification requirements defined in the CEI specification which will be satisfied by the Static Structural Tests are identified in the requirements matrix contain in Section 4.0 of this document.

5.7.1.3 Responsibility and Location. The SRB Static Structural Test is presently scheduled for the CY 1976 - CY 1977 time period. The MSFC Structures and Propulsion Laboratory will be responsible for the development of the test requirements and determination of test sequencing. The MSFC Test Laboratory will be responsible for the conduct of the test program and development and maintenance of the test facilities. All Testing of the SRB short stack will be conducted at MSFC Building 4572 (flame trench) and the structural component testing will be accomplished using the test facilities of Building 4619.

5.7.2 Electrical and Instrumentation Verification Test (EIVT). A series of engineering design verification tests will be conducted to assure the physical and functional integrity of the SRB electrical and instrumentation subsystem.

5.7.2.1 Test Configuration and Subsystems Involved. The EIVT flight electronics will consist of the E&I subsystem components identified in paragraph 4.2 and the SRM S&A device. All SMSI's/detonators, batteries, the TVC subsystem, and some DFI and OFI sensors/transducers will be simulated. The EIVT ESE will consist of LPS modules, power supplies, an Instrumentation Test Set, electrical networks, and other special test sets and breakout boxes.

5.7.2.2 Objectives. The EIVT test activities will include verification and integration testing of the SRB avionics components at the subsystem level to assure that the avionics, instrumentation and electrical power distribution subsystems contained in the Forward and Aft Booster Assemblies will function as an integrated system. Computer programs and test procedures will be developed for test and checkout of the integrated E&I subsystem, and the integrated E&I subsystem and ESE will be debugged/verified. The support equipment (including software) used for EIVT will be provided to the Assembly Contractor for module acceptance testing during DDT&E checkout operations at the launch site.

5.7.2.3 Responsibility and Location. The EIVT testing will be performed during the 1977 time frame. The MSFC SA&I Laboratory will be responsible for the development of test requirements and determination of test sequencing. The MSFC Test Laboratory will be responsible for the conduct of the test program and development and maintenance of the test facilities. EIVT testing will be conducted at MSFC Building 4708 using flight type SRB hardware.

5.7.3 3rd Static Firing. Three full scale development SRM static firing tests have been planned. The third firing in the series of development firings will be conducted using flight-type SRB hardware.

5.7.3.1 Configuration. In addition to a forward motor segment, two center segments, and an aft motor segment, the test setup will include an aft skirt, a TVC subsystem, and ESE for TVC subsystem control and monitor.

5.7.3.2 Objectives. This test will verify that the hardware design meets all specification requirements and that the manufacturing processes will produce an acceptable product. The objectives will demonstrate the following:

- | | |
|---|---|
| 1. Structural integrity | 8. Nozzle structural integrity |
| 2. Ballistic performance | 9. Internal insulation performance |
| 3. Motor design and manufacturing processes | 10. Thrust reproducibility |
| 4. Vibro-acoustic and thermal environment | 11. Reusability of case, igniter, and nozzle components |
| 5. Acceptability of design changes | 12. Dynamic thrust vector alignment |
| 6. Factors for predicting ballistic performance of production motors. | |
| 7. Ignition system performance | |

13. Nozzle performance
14. TVC interface
15. TVC Subsystem performance

5.7.3.3 Responsibilities and Location. The SRM contractor (Thiokol) will conduct the static firing tests at his test facilities in compliance with test plans which will be reviewed and approved by MSFC. MSFC will provide to the SRM contractor as GFE, the SRB flight type hardware required for the test configuration. The SRM contractor will conduct a post-test analysis of hardware and motor performance and provide to MSFC within 24 hours after the test, a "Contractors Flash Report" covering critical parameters such as pressure, thrust, and thrust vector angle. The final test report will be forwarded to MSFC thirty working days after completion of the static test.

5.7.4 Mated Vertical Ground Vibration Test. A series of integrated ground vibration tests will be conducted to substantiate the coupled dynamic math models of the Orbiter/ET/SRB used for the Space Shuttle load and flight control analyses.

5.7.4.1 Configuration. The test configuration consists of the Orbiter, ET and SRB's (2). The SRB's used will be loaded with inert propellant and a minimum of two SRB propellant loading configurations will be used. The first represents the launch condition with a fully loaded SRB. The second simulates burn out condition. The SRB's will be flight configured except that the recovery subsystem and OFI and DFI subsystem components will be mass simulated. The elements will be soft supported in the vertical position during the tests to approximate the in-flight conditions.

5.7.4.2 Objectives. Test results of the MVGVT program applicable to the SRB will be used to update the SRB math models for flight configuration. The SRB will be used in the tests primarily as an element of the combined Shuttle configuration to enable valid data to be taken of the dynamic performance of the mated Shuttle configuration. The primary SRB objective is to measure the modal frequency, shapes, and damping characteristics of the SRB when mated to the Shuttle vehicle. The test data will be compared with the predicted analytical values and the resulting analysis will verify the dynamic math model of the combined elements (Orbiter, SRB, ET, and linkages), or provide the data to correct the stiffness and mass matrices that make up the math models. The test data, when analyzed, will verify the correctness of the SRB and ET interface loads, and substantiate the SRB dynamic and combined loads analyses.

5.7.4.3 Responsibilities and Location. The MGVGT program will take place during CY 1978 and will be conducted in the test facilities at MSFC. The test requirements will be prepared by the Shuttle system contractor. MSFC will support the system contractor in preparation of the test plan. MGVGT test procedures will be prepared by the MSFC test laboratory.

5.7.5 Shuttle Avionics Integration Laboratory (SAIL). A description of the SAIL is contained in MVP Volumes I and II. No further amplification is considered necessary. One set of SRB operational flight avionics type E&I hardware will be provided to the SAIL for Shuttle mated-element avionics and software verification tests. The results of these tests will complement the EIVT tests to confirm design mechanization.

5.7.6 SRB Vibroacoustic Test. Deleted.

5.7.6.1 Configuration. Deleted.

5.7.6.2 Objective. Deleted.

5.7.6.3 Responsibilities and Location. Deleted.

5.7.7 ET/SRB Separation Tests. The ET/SRB Separation Tests will verify the functional operation of the separation system while exposed to predicted flight loads.

5.7.7.1 Test Configuration and Components Involved. The configuration for the SRB/ET separation test will consist of flight type forward SRB/ET attachment hardware, three aft attach struts, ordnance and electrical umbilicals. This hardware will be mounted in test fixtures that will have the capability of simulating flight induced loads that occur at separation.

5.7.7.2 Objectives. As stated above, the principal objective of the separation tests is to verify the functional operation of the separation mechanism for various design conditions while the external tank and SRB's are exposed to predicted flight loads. The resulting separation trajectories will be assessed for adequate clearance for all critical separation modes and conditions.

5.7.7.3 Responsibility and Location. The SRB/ET separation tests are scheduled to begin the last quarter of 1976 at MSFC in Building 4019. The MSFC SA&I Laboratory is responsible for development of test requirements. Preparation of the test plan and procedures and the conduct of the test program will be performed by the MSFC Test Laboratory.

6.0 GROUND SUPPORT SYSTEM VERIFICATION

6.1 GENERAL. The overall objectives of the ground support system verification program shall be to provide assurance that the ground system has been designed and manufactured in a manner that will support the development, acceptance test, and operational activities of the Space Shuttle Program.

The GSE verification program shall consist of development, in-process tests and acceptance tests, and will include both ground software and hardware. A development test program shall be implemented to verify the design adequacy of newly designed equipment and extensively modified existing equipment.

Specific objectives of the GSE verification program are (1) to assure concurrent development of GSE, (2) to verify equipment reliability and safety, (3) to verify that equipment functions as intended, (4) to verify that equipment meets requirements under operational conditions and environment, and (5) to verify that integrated GSE and facility systems meet requirements.

6.2 DEVELOPMENT ACTIVITIES

6.2.1 Design Verification. To the greatest extent possible, design verification will be satisfied by analysis. Testing will be performed where analysis alone is inadequate to provide the required confidence.

6.2.2 Support Equipment Operating Procedures and Software. During the development phase, support equipment operating procedures and software will be developed for use during the operational phase.

6.2.3 Electromagnetic Compatibility. Electromagnetic compatibility will be verified during E&I verification testing (EIVT). Only equipment whose failure or premature function could cause loss of vehicle systems, loss of personnel capability, or destruction of ground systems will be subjected to susceptibility tests at the subassembly level (black box).

6.3 CERTIFICATION

6.3.1 Certification by Testing. Certification of ground support equipment by testing, when required, will be performed on production configured and items to verify that the functional performance of components and assemblies in specified environments is in compliance with design and performance specifications. Test requirements will be based upon function of the equipment. Tests will be performed only to the extent needed to qualify the critical function. The SRB Project Office will identify and approve that GSE for certification which requires additional testing or analysis required in addition to acceptance testing. Certification will be based on expected environmental conditions, operational conditions, or hardware failure which could cause loss of vehicle systems or personnel capability.

6.3.2 Testing of Components and Subassemblies. Testing of components and subassemblies will be accomplished on the highest practical level of assembly. Verification of the load handling capability of support equipment items such as slings, dollies, pallets, etc., will be performed by applying load(s) sufficient to demonstrate the desired safety margin of the item tested.

6.3.3 External Environments. External environments selected will be those which the hardware is expected to experience in its service life. Environmental tests may be performed with one or several environmental parameters imposed, depending upon the probable dependence, test realism, and practicality of the test configuration. The environment levels and durations will be characteristic of the worst case operational conditions at any test site and will demonstrate the design integrity.

6.4 ACCEPTANCE AND STATION SET VALIDATION

6.4.1 Acceptance Verification. All support equipment shall be subjected to an acceptance verification to demonstrate that the equipment satisfies design requirements as documented in applicable acceptance specifications.

6.4.2 Acceptance Testing. Acceptance testing shall be non-destructive and is to be planned such that rework or repair of the equipment shall not be required subsequent to successful test completion. The test shall encompass operation of the units or components in their normal modes in an ambient environment.

6.4.3 Final Acceptance. Final acceptance of electrical GSE shall be accomplished at the functional set or station set level for which that GSE is programmed for use. STE and mechanical GSE shall be accepted at the end item level and validated at the using site.

All acceptance checkout and station set validation test requirements shall be structured to adequately verify the equipment while minimizing unnecessary redundant testing.

7.0

DEFINITIONS

For the purpose of this MVP document, the following definitions will apply:

Acceptance Testing - Tests to determine that a part, component, subsystem, or system is capable of meeting performance requirements prescribed in procurement specifications or other documents specifying what constitutes the adequate performance capability for the item in question.

Assembly and Buildup - The process of combining components to form major assemblies and/or subsystems, which in turn are combined to form a complete SRB element.

Certification - Qualification tests, major ground tests, and other test and analysis required to determine that the design of hardware from the component through the subsystem level meets requirements.

1. Certification By Testing - The process of conducting tests which normally are considered qualification tests plus specific additional tests of components and subsystems and higher levels of assemblies required to certify that the hardware design meets established design requirements. Certification by testing does not generally include development, piece-part qualification, acceptance, or checkout tests except where such tests are specifically identified as required for certification.

2. Certification By Analysis

- a. Analysis performed to satisfy certification objectives when testing under simulated mission conditions is not feasible or cost effective, or the need exists to extrapolate test data beyond the performed test points.
- b. Analysis performed to show that an article is similar or identical in design, manufacturing process, and quality control to another that has been previously certified to equivalent or more stringent criteria.

Checkout - Verification that the hardware functions within prescribed limits when the subsystems are operated alone, or together as an integrated system.

Component - A combination of parts, devices, and structure, usually self-contained, which performs a distinctive function in the operation of a subsystem. A component is commonly called a "black box" (i. e., IEA, HPU, Frustum, Drogue Parachute, BSM, Igniter).

Development Testing - That testing performed with minimum rigors and controls to verify a design approach.

Element - A major item of hardware which, when combined with other major hardware items, forms the Shuttle System. The elements of the Shuttle System consist of the following: Orbiter, SRB, and ET.

Fail-Safe Testing - Tests to verify that a failure in one item of hardware will not cause the malfunction or unintentional operation of another item of hardware.

Functional Paths - A serial set of one or more functional elements (i. e. LRU's) constrained by the following:

- (a) It is either the only path capable of performing the given function, or it is the smallest set (shortest string) of serial elements for which identical or similar serial elements can be substituted by automatic or manual control (on board or via GSE) to perform the same function via a redundant path for fail safe or fail operational capability.
- (b) The string may contain non-controllable redundancies within itself to assure a satisfactory MTBF for the string (i. e. redundant components within an LRU), but must not contain redundancies needed to provide fail operational or fail safe capabilities.
- (c) Any point along a path which supports several "downstream" paths must constitute the termination point of the "upstream" functional path and the starting point of "downstream" functional paths.

GSE Station Set - The GSE and associated software to provide overall ground support to a specific activity or phase of vehicle assembly checkout, and launch.

Incipient Failure - A hardware failure due to human error which goes undetected during acceptance tests and/or checkout, but later affects flight operation.

Life Certification - A test structured to certify that design life requirements (maximum operating time/cycles without degradation of performance beyond acceptable limits before replacement/refurbishment) have been met.

Major Ground Tests - Those ground tests which involve the combination of system elements, complex facilities, large or expensive hardware segments or a combination of the above.

Overstress Testing - Tests which consist of increased time at certification levels and/or increased severity of the applied environmental stress (i. e., vibration, thermal, altitude, etc).

Proof Test - A structural test generally conducted on pressure vessels, miscellaneous structural components, structural assemblies or mechanisms to ensure confidence in the manufactured article.

Qualification Tests - Those tests conducted as part of the certification program to demonstrate that design and performance requirements can be realized under specified conditions.

• Stacking - The process of alternately mating the major booster assemblies and motor segments on the MLP, resulting in two completely assembled SRB elements.

Subsystem - A major functioning entity consisting of two or more hardware items within the elements of the Shuttle System. E&I, for instance, shall be referred to as an SRB subsystem.

System - The principal functioning entity of the Orbiter, Space Shuttle Main Engines, External Tank, and Solid Rocket Booster mated into a launch vehicle configuration forming the Shuttle System.

8.0 ACRONYMS AND ABBREVIATIONS

ACO	Assembly and Checkout
APU	Auxiliary Power Unit
BSM	Booster Separation Motors
CEI	Contract End Item
CHL	Certified Hardware List
CIL	Critical Items List
C/O	Checkout
COFR	Certificate of Flight Readiness
COQ	Certificate of Qualification
DDT&E	Design, Development, Test and Evaluation
DFI	Development Flight Instrumentation
EEE	Electrical, Electronic, and Electromechanical
E&I	Electrical and Instrumentation
EIVT	Electrical and Instrumentation Verification Test
EMC	Electromagnetic Compatibility
ESE	Electrical Support Equipment
ET	External Tank
FM	Frequency Modulation
FMEA	Failure Mode Effect Analysis
FP	Functional Path
FRF	Flight Readiness Firing
FRR	Flight Readiness Review
FSM	Fuel Supply Module
FVF	First Vertical Flight
GFE	Government Furnished Equipment
GSE	Ground Support Equipment
GSS	Ground Support System
HPU	Hydraulic Power Unit
ICD	Interface Control Document
IEA	Integrated Electronics Assembly
JSC	Johnson Space Center
KSC	Kennedy Space Center
LPS	Launch Processing System
LRU	Line Replaceable Unit

MDM	Multiplexer Demultiplexer
MLP	Mobile Launch Platform
MSFC	Marshall Space Flight Center
MTBF	Mean Time Between Failures
MVGVT	Mated Vertical Ground Vibration Test
MVP	Master Verification Plan
NASA	National Aeronautics and Space Administration
OFI	Operational Flight Instrumentation
OMRSD	Operation and Maintenance Requirements and Specifications Document
ORI	Operational Readiness Inspection
PCM	Pulse Code Modulation
RSS	Root Sum Square
S/S	Subsystem
S&A	Safe and Arm
SAIL	Shuttle Avionics Integration Laboratory
SE	Support Equipment
SMSI	Standard Manned Space Flight Initiator
SMVP	Shuttle Master Verification Plan
SRB	Solid Rocket Booster
SRM	Solid Rocket Motor
SRU	Shop Replaceable Unit
SSF	Space Shuttle Flight
STE	Special Test Equipment
TBD	To Be Determined
TVC	Thrust Vector Control
VAB	Vertical Assembly Building
VFT	Vertical Flight Test

NASA-MSFC-C

GEORGE C. MARSHALL SPACE FLIGHT CENTER SPECIFICATION CHANGE NOTICE No. <u>005</u>		PAGE 1 OF 1 DATE: April 8, 1976 SUPERSEDING:
1. ECP/ECR NUMBER:	2. PROGRAM - ITEM: SRB	3. SPEC. NUMBER: SE-019-019-2H, Rev. A
4. CONTRACT NUMBER: N/A	5. APPROVAL AUTHORITY/DATE: SB3-00-0568 4/20/76	FILE OPPOSITE/REPLACE SPEC. See block 7 PAGE NO.
6. EFFECTIVITY: SRB 001 + Subs		
7. EFFECT OF CHANGE: Page 5-9:		
<p>WAS: 5.7.6 <u>SRB Vibroacoustic Test.</u> Several tests will be conducted to verify the nose assembly and forward skirt for structural adequacy to critical environmental levels.</p> <p>5.7.6.1 <u>Configuration.</u> The test article will consist of the nose assembly (nose cap and frustum) and the forward skirt. The components/simulators will be attached with flight type brackets. The aft end of the forward skirt will be provided with an acoustic closeout simulating the forward motor case dome.</p> <p>5.7.6.2 <u>Objective.</u> The test will verify dynamic design and test criteria, and qualify flight structural hardware components to the dynamic flight environment.</p> <p>5.7.6.3 <u>Responsibilities and Location.</u> MSFC Systems Dynamics Laboratory will be responsible for the test requirements. JSC will be responsible for the test plan. The test will be performed in the Vibro-Acoustic Facility at JSC. Estimated test start is August 1978.</p> <p>IS: 5.7.6 Deleted</p> <p>5.7.6.1 Deleted</p> <p>5.7.6.2 Deleted</p> <p>5.7.6.3 Deleted</p>		

1. NUMBER: EL41-0426	2. PCN: 01268	MSFC ENGINEERING CHANGE REQUEST <i>(See Instructions on reverse)</i>	3. DATE: 4/12/76	4. PAGE 1 OF 1
5. TO: SA41/George B. Hardy		6. THRU: EE11/W. P. Horton <i>W. P. Horton</i>		7. FROM: EL43/L. Malmay
8. TITLE OF CHANGE: Rebaselining to the Alternate Program on Schedules and Requirements				
9. RECOMMENDED PRIORITY: <input type="checkbox"/> Emergency <input type="checkbox"/> Urgent <input checked="" type="checkbox"/> Routine			10. NEED DATE:	
11. PROGRAM(S)/PROJECT(S) AFFECTED: SRB			12. END ITEM(S) AFFECTED BY NOMENCLATURE: SRB Subassemblys	
13. RECOMMENDED EFFECTIVITY: SRB Vibroacoustics Test			14. BASELINE DOCUMENTATION AFFECTED (Specs, ICD, etc.): SE-019-019-2H, Rev. A SRB Verification Plan	
15. RELATED CHANGES (ECR, ECP, CR, etc.) BY NUMBER: SRB CCBD SB3-00-0136A				
16. JUSTIFICATION FOR CHANGE (Include effect if not incorporated) (If necessary, continue on MSFC - Form 2327-1, continuation sheet): This ECR is submitted to satisfy a requirement of CCBD SB3-00-0136A against EE11/P. Madole.				
17. EFFECTS ON: <input type="checkbox"/> Hardware <input type="checkbox"/> Facility <input type="checkbox"/> Schedule (See Enclosure _____ for impact) <input type="checkbox"/> Other (Specify) <input type="checkbox"/> Software <input checked="" type="checkbox"/> Requirements Documentation <input type="checkbox"/> Cost (Estimated cost included in Enclosure _____)				
18. DESCRIPTION OF CHANGE (Include reference to enclosures) (If necessary, continue on MSFC - Form 2327-1, continuation sheet): SCN 005 to the SRB Verification Plan, Rev. A, is submitted to delete the requiremer for the SRB Vibroacoustics Test as approved by SB3-00-0136A.				
19. SIGNATURE OF ORIGINATOR: <i>L. Malmay</i> L. Malmay		DATE: 4/14/76	TELEPHONE NUMBER: 453-1662	OFFICE SYMBOL: EL43
20. CONCURRENCE				
SIGNATURE & ORGANIZATION		DATE	SIGNATURE & ORGANIZATION	
21. TECHNICAL APPROVAL				
SIGNATURE & ORGANIZATION		DATE	SIGNATURE & ORGANIZATION	